

**Size and Age of British Columbia
Sockeye Salmon (*Oncorhynchus nerka*)
in Relation to Environmental Factors
and the Fishery**

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SOCKEYE SALMON (Oncorhynchus nerka)
IN RELATION TO ENVIRONMENTAL FACTORS AND THE FISHERY

by

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ABSTRACT

W. E. Ricker. 1982. Size and age of sockeye salmon (*Oncorhynchus nerka*) in relation to environmental factors and the fishery. Can. Tech. Rep. Fish. Aquat. Sci. 1115: ix + 117 p.

The major sockeye runs in British Columbia have experienced various changes in the relative abundance of fish of different freshwater and ocean ages. In Area 3, the Nass region, sockeye having 1 year of freshwater growth and 4 years of ocean growth (life-history type 1/4) have gradually become about twice as numerous as the 2/3 type since 1940, reversing the original situation. At the same time type 1/3 has increased from about 10% to 25%. In Area 4, the Skeena region, sockeye are now mainly of the 1-freshwater type. The 2-freshwater fish were never a major component, coming mainly from several of the smaller lakes, and they have decreased. Among the 1-freshwater type, the ratio of 3-ocean to 4-ocean fish has fluctuated greatly, but the various possible causes have not been sorted out. In part, the changes are related to an early 5-year and a later 4-year cycle of abundance. In Area 9, the Rivers Inlet run to Owikeno Lake has always been mainly 1-freshwater. The ratio of 4-ocean to 3-ocean fish has varied, and there have been 5-year and 4-year cycles similar to those on the Skeena, but peaking one year later. Fraser River sockeye have always been mainly of the 1/3 type, although local stocks exhibit diversity. Most stocks exhibit dominance of one line out of the four. To-day the big populations are in different lines at different lakes, but in 1913 and earlier all studied upriver populations were dominant in the 1901 line.

On the whole, there have been only small changes in the average size of sockeye captured, from 1912 through 1980. However, from about 1950 most statistical Areas have registered small decreases in size, averaging 0.3-0.4 lb (140-180 g) over all Areas. Individually these decreases are non-significant statistically, but an overall effect is made probable by the preponderance of decreases over increases in different Areas (26 decreases, 10 increases); coupled with the fact that all but one of the increases are from Areas of very small catches. However, the negative trends since 1950 owe much to a 1950-54 interval of unusually large size in almost all Areas, so it is too soon to be sure there is a sustained decline in size.

Sockeye sizes of the 4 major runs are positively correlated, particularly when residuals from their linear trends are compared. The large sizes of 1950-54 were preceded and followed by small sizes in 1944-49 and 1955-61.

Mean size and quantity of fish landed each year are positively correlated. In the runs having two important ocean ages this is merely an arithmetic artifact. On the Fraser it occurs because fish of the 1902 line are congenitally larger than the other lines, and since 1926 that line has been the most abundant one.

A correlation analysis shows that the major contribution to similarity in adult size of two groups of sockeye is made by length of

ocean life. Among fish of the same ocean age, similarity is increased if most or all of their ocean growth is in the same calendar years. Having the same length of freshwater life may make a contribution to similarity in adult size, but if so it is very minor. When all such differences are eliminated, it turns out that observed year-to-year variability in size is reduced by 30% to 47% (mean 38%), which is an estimate of the contribution of oceanic conditions to observed variability. The "noise" in the data is estimated as 45%, from the variability of the difference in size between males and females of the same age type and year-class, so that the contribution of oceanic conditions to the true year-to-year variability in size is increased to 69%.

In spite of this large influence of ocean conditions upon sockeye size, little success was achieved in the attempt to identify causal factors or their correlatives. Neither single-year nor 2-year mean salinities at Station P (50°N, 145°W) or at coastal stations exhibited promising correlations with sockeye sizes. Correlations with temperature were mostly negative, supporting an earlier discovery by Killick and Clemens. However, in combination with a decreasing trend in ocean temperatures, this would tend to increase mean size somewhat, the reverse of the observed trend since 1950.

Average sizes of sockeye caught have been greatest in the troll fishery, somewhat less in the gillnet fisheries, and least in the seine fishery. In runs of the central and northern coast, where two ocean ages occur in numbers, this has meant that spawning stocks contain more of the faster-growing 3-ocean fish and fewer of the larger but slower-growing 4-ocean fish. These two opposed factors make the net effect on average size unpredictable, and size has in fact not changed very much since 1950 (the average decrease is a non-significant 0.28 lb or 127 g). What is very striking is that the gillnet fisheries have harvested fish mainly from the middle of the size range, as described by Foskett. As a result, the 4-ocean sockeye have gradually become larger and the 3-ocean fish smaller, the difference between them having increased by more than a pound (about 500 g), as described by Godfrey. There have also been small changes in the relative size of the two sexes in fish of the same life-history type, which may be explicable in terms of the selectivity of the fishery if inheritance of size is partly sex-limited. At Owikeno the males have even become smaller than the females in the age 1/3 category, but not in the 1/4 category.

The Fraser run contains only one life-history type of major importance, 1/3, so the smaller fish that have been favoured for reproduction have not been younger ones having a fast growth rate, as in the north. As a result, Fraser sockeye have decreased more in recent years (about 0.66 lb or 300 g in 1951-75) than did those of the northern runs, in spite of the fact that the Fraser gillnet fishery has been less selective of the larger fish.

There is no good evidence for any effect, on growth, of competition between sockeye and the chum or pink salmon that mature in the same calendar year. However, for the Fraser run only there is a significant positive correlation between adult size of sockeye and adult size of the pink salmon that go to sea in the same calendar year. If this is a real effect, it probably reflects the fact that they share the same vicissitudes of life in the southern straits during part of their first year of marine life.

Key words: Sockeye salmon, Oncorhynchus nerka, 1971-75 catches, British Columbia, size at maturity and ocean temperatures, effects of selective fishing on age at maturity, on size at a given age, and on the size difference between the sexes.

RÉSUMÉ

W. E. Ricker. 1982. Size and age of sockeye salmon (Oncorhynchus nerka) in relation to environmental factors and the fishery. Can. Tech. Rep. Fish. Aquat. Sci. 1115: ix + 117 p.

Il s'est produit, dans les principales remontes de saumons rouges en Colombie-Britannique, divers changements dans l'abondance relative des poissons de différents âges dulçaquicoles et océaniques. Dans le secteur 3, la région de Nass, les saumons rouges qui ont connu une croissance d'un an en eau douce et de 4 dans l'océan (cycle vital du type 1/4) sont devenus depuis 1940 graduellement environ deux fois plus nombreux que ceux du type 2/3, renversant ainsi la situation originelle. Pendant ce temps, ceux du type 1/3 ont augmenté d'environ 10 à 25 %. Dans le secteur 4, la région de Skeena, les saumons rouges sont maintenant constitués surtout d'individus du type 1 (un an en eau douce). Ceux qui ont passé deux ans en eau douce n'ont jamais constitué un élément important, provenant surtout de plusieurs lacs de moindre importance, et leur nombre a diminué. Parmi les poissons du type 1 ou en eau douce, le rapport entre ceux qui ont passé 3 ans dans l'océan et ceux de 4 ans a varié beaucoup, mais les diverses causes qui peuvent expliquer ce phénomène n'ont pas été déterminées. Les changements sont liés en partie à un cycle d'abondance de 5 ans suivi d'un cycle de 4 ans. Dans le secteur 9, la remonte de l'inlet Rivers au lac Owikeno a toujours été constitué d'individus qui ont séjourné 1 an en eau douce. Le rapport entre le nombre de poissons qui ont passé 4 ans en mer et ceux de 3 ans a varié; il y a eu également des cycles de 4 et de 5 ans semblables à ceux observés dans la rivière Skeena, mais atteignant un sommet un an plus tard. Les saumons rouges du fleuve Fraser ont toujours été constitués surtout d'individus du type 1/3, bien que les populations locales soient diversifiées. Dans la plupart des populations, une génération parmi les quatre domine. Aujourd'hui, différentes générations composent les populations importantes de différents lacs, mais en 1913 et auparavant, la génération de 1901 était dominante dans toutes les populations étudiées en amont.

Dans l'ensemble, de 1912 à 1980, il n'y a eu que de légers changements dans la taille moyenne des saumons rouges capturés. Cependant, à partir de 1950 à peu près, on a noté, dans la plupart des secteurs statistiques, de légères diminutions de taille, de 0,3 à 0,4 lb (140 à 180 g) en moyenne pour tous les secteurs. Prises séparément, ces diminutions ne sont pas significatives statistiquement, mais globalement il est probable que la

prépondérance des diminutions sur les augmentations dans différents secteurs (26 diminutions pour 10 augmentations) associée au fait que toutes les augmentations, sauf une, ont été enregistrées dans des secteurs où les prises sont très faibles, ait eu un effet. Cependant, la tendance vers la baisse observée depuis 1950 est due en bonne partie à une intervalle, entre 1950 et 1954, où la taille des individus a été exceptionnellement grandes dans presque tous les secteurs, de sorte qu'il est trop tôt pour affirmer qu'il y a une baisse constante de taille.

La corrélation entre les tailles de saumons rouges des 4 principales remontes est positive, en particulier lorsqu'on compare ce qui reste de leurs tendances linéaires. Les individus de grande taille des années 1950 à 1954 ont été précédés et suivis entre 1944 et 1949 et entre 1955 et 1961 par des individus de petite taille.

La corrélation est positive entre la taille moyenne et la quantité de poissons débarqués chaque année. Le fait qu'il y a deux goupes d'âge océanique importants dans les remontes est dû simplement à un artéfact arithmétique. Sur le fleuve Fraser, cela se produit parce que les poissons de la génération de 1902 sont à leur naissance plus gros que ceux des autres générations et parce que, depuis 1926, cette génération a été la plus abondante.

Une analyse de corrélation montre que c'est la durée du séjour dans l'océan qui est le principal facteur responsable de la similitude de taille des adultes des deux groupes de saumon rouge. Parmi les poissons du même âge océanique, il y a une plus grande similitude si la plus grande partie ou toute leur croissance se produit dans les mêmes années civiles. Le fait que les poissons ont séjourné en eau douce le même laps de temps peut avoir une influence sur la similitude de taille des adultes, mais s'il est ainsi cette influence est très faible. Si on élimine toutes ces différences, cette variabilité de taille observée d'une à l'autre se trouve réduite de 30 à 47 % (moyenne de 38 %), ce qui est une estimation de l'influence des conditions océaniques sur la variabilité observée. Le "bruit" dans les données est estimé à 45 %, provenant des variations de différence de taille entre mâles et femelles de la même catégorie et classe d'âge, de sorte que l'influence des conditions océaniques sur les variations réelles de taille d'une année à l'autre s'accroît à 69 %.

Malgré cette influence importante des conditions océaniques sur la taille des saumons rouges, nous avons obtenu peu de succès dans notre tentative d'identifier les facteurs causals ou leurs corrélatifs. Les salinités moyennes calculées pour un an ou pour deux ans à la station P (50°N, 145°O) ou aux stations côtières n'ont montré ni l'une ni l'autre de corrélation prometteuse avec les tailles des saumons rouges. Les corrélations avec la température se sont révélées pour la plupart négatives, confirmant ce qu'ont découvert Killick et Clemens. Néanmoins, si l'on tient compte de la tendance à la baisse de la température de l'océan, la taille moyenne aurait tendance à augmenter un peu, ce qui est le contraire de la tendance observée depuis 1950.

La taille moyenne des saumons rouges capturés a été plus grande dans la pêche à la traîne, un peu moins grande dans la pêche aux filets maillants et encore moins dans la pêche à la senne. Le fait qu'il y avait beaucoup d'individus de deux catégories d'âge océanique dans les remontes de la côte centrale et de la côte du nord veut dire que les stocks de reproducteurs comptaient davantage de poissons de 3 ans océaniques à croissance plus rapide que de poissons de 4 ans qui étaient plus gros mais dont la croissance était plus lente. Comme ces deux facteurs s'opposent, on ne peut prédire le résultat net sur la taille moyenne et, de plus, la taille n'a en fait pas beaucoup changé depuis 1950 (la baisse moyenne est seulement de 0,28 lb ou 127 g). Ce qui est très frappant, c'est que les poissons capturés aux filets maillants étaient surtout des individus dont la taille se situait au centre de l'échelle des valeurs, tel qu'exposé par Foskett. Comme résultat, les saumons rouges qui ont passé 4 ans dans l'océan sont devenus graduellement plus gros et ceux de 3 ans plus petits, la différence entre ces deux groupes ayant augmenté de plus d'une livre (environ 500 g), comme l'expose Godfrey. Il y a eu également de petits changements dans la taille relative des deux sexes chez les poissons ayant le même type de cycle vital, ce qui peut s'expliquer en fonction de la sélectivité de la pêche si l'héritage de la taille est en partie limitée par le sexe. Au lac Owikeno les mâles sont même devenus plus petits que les femelles dans la catégorie d'âge 1/3, mais non dans la catégorie 1/4.

La remonte du fleuve Fraser comprend seulement un type de cycle vital d'importance, le type 1/3, de sorte que les poissons plus petits qui ont été favorisés pour la reproduction n'ont pas été les plus jeunes dont la croissance est rapide, comme poids, depuis quelques années, chez les saumons rouges du fleuve Fraser (environ 0,66 lb ou 300 g entre 1951 et 1975) que chez ceux des remontes du Nord, malgré le fait que la pêche aux filets maillants dans le fleuve Fraser a éparqué un plus grand nombre de gros poissons.

Il n'y a pas de preuve probante que la compétition entre le saumon rouge et le saumon kéta ou le saumon rose ait un effet quelconque sur la croissance. Cependant, pour la remonte du significative entre la taille adulte des saumons rouges et celle des saumons roses qui se rendent à la mer pendant le même année civile. Cet effet, s'il est réel, reflète probablement le fait que ces poissons partagent les mêmes conditions d'existence, dans les détroits du Sud, pendant une partie de leur première année de vie en mer.

Mots-clés: saumon rouge, Oncorhynchus nerka, prises effectuées entre 1971 et 1975, Colombie-Britannique, taille à la maturité et températures de l'océan, effets de la pêche sélective sur l'âge à la maturité, sur la taille à un âge donné et sur la différence de taille entre les sexes.

1. INFORMATION OF AGE, SIZE, AND ABUNDANCE OF SOCKEYE

1.1. Age and life-history type

From 1912 to 1972 age determinations were made from samples taken from net-caught sockeye of the major British Columbia sockeye stocks. Data for the Fraser region have been summarized by Killick and Clemens (1963), and for other Areas by Bilton et al. (1967). More recent samples have been reported annually by Bilton and co-workers until the sampling program was discontinued after 1972.

Freshwater age and ocean age were recorded for the two sexes separately. Because all the fish to be considered have completed or almost completed their growth, it is convenient to use the system of Biette et al. (1981) to distinguish life-history types; for example, the code number 1/4 represents sockeye that spent one growing season in fresh water and 4 in the ocean, the first and last ocean seasons being somewhat abbreviated. This is equivalent to 52 in Gilbert's system, and to 1.3 in the system used by Bilton et al.

1.2. Lengths and transformations

The series of papers, cited above, that reported sockeye ages also included the lengths of the fish, and in most cases weight also. Changes were twice made in the method of measuring length. First to be used was the fork length measured on the curve of the body using a tape. Starting in 1942 a measuring board was used, which gives a shorter length. Starting in 1958 the "postorbital-hypural" (PH) length was used, measured from the hind margin of the orbit to the end of the hypural bone of the tail.

In this paper the fork length by measuring board is used unless otherwise stated, and all lengths are quoted in millimeters. Lengths for 1941 and earlier have been adjusted by subtracting 0.7 inch (Nass and Skeena) or 0.8 inch (Rivers Inlet and Fraser), as determined by Clemens. Bilton et al. converted all pre-1958 fork lengths (F) to PH lengths (H) using two regression equations based on about 4000 replicate measurements:

$$\begin{array}{lll} \text{Males:} & H = 30.47 + 0.7689F & (1) \\ \text{Females:} & H = 21.47 + 0.7861F & (2) \end{array}$$

These equations are the ordinary regression of PH length on fork length. Ricker (1973) showed that the GM functional regression (= reduced, or standard, major axis) is more appropriate for length conversions. Unlike ordinary regressions, the same GM line can be used to convert in either direction (F to H or H to F). Unfortunately, the calculations from which expressions (1) and (2) were obtained are no longer available, so the corresponding GM regressions cannot be calculated. Instead, new runs were made on the local computer using essentially the same measurement data as stored on cards; these included 1756 males and 2353 females. The ordinary regression equations corresponding to (1) and (2) were:

$$\begin{array}{ll} \text{Males:} & H = 61.18 + 0.7286F \quad (3) \\ \text{Females:} & H = 42.18 + 0.7672F \quad (4) \end{array}$$

No one is able to explain why there should be this much difference from equations (1) and (2), but the computer crew swear that the more recent result is correct.

The GM regressions from the same runs are:

$$\begin{array}{ll} \text{Males:} & H = 22.59 + 0.7933F \quad (5) \\ & F = -28.47 + 1.2605H \quad (6) \\ \text{Females:} & H = -0.20 + 0.8394F \quad (7) \\ & F = 0.24 + 1.191H \quad (8) \end{array}$$

Expressions (5) and (6) are the same equation in a different form, as are (7) and (8). The two lines cross at $F = 494$, $H = 415$. This is unexpected, because if there is any real difference between the sexes, we should expect the males to have a somewhat longer head and hence a larger H:F ratio at all adult lengths, not just up to 494 mm. (The longer head could result from some of the males measured having started the snout elongation that occurs at maturity, or possibly a small difference exists at all ages.)

In view of this crossing-over, it seemed best to use the same equation for both sexes. The intercepts in equations (7) and (8) are practically zero, and those for (5) and (6) do not differ significantly from zero. Accordingly, a simple equation of proportion was used to change in either direction, as follows:

$$\begin{array}{ll} H = 0.821F & (9) \\ F = 1.218H & (10) \end{array}$$

This equation was "best guess" before the results of the computer runs were available. It seems as good as any, although the simpler expression $F = 1.2H$ would equally useful.

1.3. Weight and its computation from length

Changes in weight are relatively greater and of more intrinsic interest than changes in length, although the two go together on the whole, and presumably no change has been made in the definition of weight over the years. On the other hand, weight varies more than length, and there are anomalies. For example, for 1915-18 on the Fraser the weights are much less than expected from the corresponding lengths: perhaps the scale was faulty. Also, routine weighings were discontinued after 1965, except that for the Fraser run mean weights of age 1/3 sockeye are available in the Annual Reports of the International Pacific Salmon Fisheries Commission.

The missing weights can be estimated from lengths, given a relationship between mean weight and mean length of the form:

$$w = aL^b \quad (11)$$

$$\text{or } \log(w/a) = b \log(L) \quad (12)$$

However there is a simpler alternative, namely to use the logarithm of length for comparative purposes. Expression (12) shows that the logarithm of length is proportional to the logarithm of weight, regardless of the size of the exponent b or the parameter a , provided both are fixed. (In effect, " a " merely changes the unit in which weight is measured.) Hence a graph of values of $\log L$ exhibits exactly the same fluctuations from year to year as a graph of values of $\log w$ computed from L . Such $\log L$ values do not, of course, reflect the effects of any variability in weight due to differences in "condition" of the fish from year to year.

It can be argued whether it is weight or its logarithm that is the better index of the effects of heredity and environment on sockeye growth: basically, whether the effects in question act additively or multiplicatively. However, for any given life-history type in a given river, the range of mean weights from year to year is not very great, so there is not much difference between using weight and using its logarithm.

1.4. Combined size indices

Base-10 logarithms of length or weight are shown for each sex and each important life-history type separately in Fig. 1-5, and for the sexes combined in Fig. 6-7. For most of the comparisons between Areas and with oceanographic conditions a single index is used for each run. For the Fraser River region (Area 29, etc.) the annual mean weights of sockeye of life-history type 1/3 are the longest available series. The logarithm of whole weight in pounds is the index used, sometimes divided by 3 as explained below. For other Areas an overall index was obtained by combining lengths from each of the available life-history types. These are 1/3 and 1/4 at Owikeno, and 1/3, 2/3, 1/4, and 2/4 at the Skeena and Nass rivers; data were obtained from Bilton et al. (1965-58) and Jenkinson et al. (1969-73). The combined index used is the arithmetic average of the logarithms of the mean lengths of each sex of each important life-history type (4 items in all at Owikeno, and 8 at Skeena and Nass), all being given the same weight; these are in the "means" columns of Tables 1-3.

Given the weight:length relationship of expression (12), the logarithm of weight is proportional to logarithm of length. Using $b = 3$ and dividing the logarithms of weight by 3, the latter can be converted to an absolute scale quantitatively similar to the $\log L$ index; this similarity is useful for the graphical display in Fig. 11 but is not necessary otherwise.

Table 4 contains the combined indices for the years used in correlations with temperature, and the "residuals" from their linear regression on time. The Fraser series in column 5 can now be continued as follows: 1975, 0.2489; 1976, 0.2550; 1977, 0.2615; 1978, 0.2699; 1979, 0.2484; 1980, 0.2387.

1.5. Mean weights from catch statistics

Starting in 1951, numbers and weights of salmon caught commercially in the various commercial fishing Areas of British Columbia have been available from sales slips, and have been published annually by the Pacific Region of the Canadian Department of Fisheries and Oceans. Table 5 here summarizes the weights of sockeye taken in each type of gear from 1951 through 1975. The representativeness of these data has been discussed and confirmed (Ricker 1981).

From the complete statistical tables the average individual weights of sockeye caught can be calculated, as shown for most Areas in Table 6. These are useful for comparison with the length data, and with similar data for other species of salmon. Figures in Table 6 are based on 3000 lb or more of fish in 1951-72, on 8000 lb or more in 1973-75, and on 2000 kg or more in 1976-80. (Weights used were tabulated to the nearest 100 lb through 1972, and to the nearest 1000 lb in 1973-75. From 1976 the published data are to the nearest 1000 kg, but figures to 100 kg are available in each year's preliminary tabulations; 1 kg = 2.20462 lb.)

1.6. Size of sockeye caught by different gears

Peterson (1954) and Killick and Clemens (1963, p. 103-107) have presented details of the sizes of sockeye of the Fraser run caught by gillnets and seines. The gillnets usually caught larger sockeye than the seines, but in a few years when sockeye were unusually large the reverse was true.

Table 7 shows that, on the average, gillnetted sockeye exceeded seine-caught sockeye in size in all 12 of the Areas where comparison is possible. Using the 1951-75 catches in each Area as weighting factors, the weighted mean difference was 0.28 lb. However, this difference was greater in northern British Columbia (Areas 1-8) than in the south (Areas 12-24): 0.59 lb as compared with 0.17 lb. This difference between north and south probably reflects the greater variability in size of northern sockeye, where two ocean ages are common as compared with only one in the south. This could make for the choice of a larger mesh in gillnets.

Up to recently, troll-caught sockeye were not numerous (Table 5). In the 5 comparisons available they exceeded even the gillnetted sockeye in size, by a weighted average of 0.92 lb (Table 7). Before 1970, approximately, sockeye taken by troll were mainly an incidental catch captured when fishing for cohos or chinooks, which are larger fish, so it is not surprising that the larger sockeye were taken by this gear. However during 1971-75, when trolling directed specifically at sockeye had become much more common, the troll-caught sockeye still averaged larger than those taken by gillnet (Table 6).

1.7. Geographic distribution of sockeye landings

The fisheries statistical Areas of British Columbia are shown in Fig. 18. The different Areas along the coast produce very different quantities

of sockeye (Fig. 5). The major river is of course the Fraser. Sockeye bound for it are taken not only in its own Area 29 but also, sometimes mixed with local runs, in Areas 12-18 of Johnstone and Georgia straits and Areas 19-27 of the south and west coast of Vancouver Island. Large numbers of Fraser-bound sockeye are also taken in United States waters. Statistics of catches, in numbers and weights, taken from the "Convention waters" by both Canada and the United States are published each year in the Annual Reports of the International Pacific Salmon Fisheries Commission.

British Columbia statistical Area 10 has a good run into Smith's Inlet, and Area 9 has a larger one to River's Inlet which drains Owikeno Lake. Sockeye from these two runs are also taken in adjacent Areas to some extent. In the far north the good runs are to the Skeena and Nass rivers, taken mainly in Areas 4 and 3 respectively.

Catch statistics for the years before 1951 are available for the principal sockeye regions, usually in terms of the number of 48-lb cases that were canned. They are given in the Annual Reports of the British Columbia Fisheries Department of those years. For Areas 4 and 9 they have been converted to numbers of fish by Godfrey (1958). The same is done for the Convention-waters catches taken by both Canada and the United States in Table 7 of Killick and Clemens (1963) and in the IPSFC Annual Reports.

2. FLUCTUATIONS IN AGE COMPOSITION

2.1. Data

The sources cited in Section 1.1, particularly Bilton et al. (1967), give the relative number of the different life-history types in each year's samples. These percentages are averaged by 5-year periods (mainly) in Fig. 8-10, which give a general picture of the trends in three northern areas. Note that these averages are not a perfect reflection of relative abundance of the age types in the runs, for two reasons. One is that abundance varies from year to year, whereas the averages give all years equal weight. Another deficiency is that the samples represent the catch only, whereas it is shown in Section 2.3 that escapement typically has a somewhat different age structure. The most glaring difference is that jack sockeye, age 1/2, are scarcely represented in the gillnet catch whereas they can be fairly numerous in the escapement. However, apart from jacks, Fig. 8-10 are adequate to give a general picture of changes that have occurred in the age composition of the runs. Godfrey (1958, Fig. 5) has plotted estimates of the year-by-year changes in the ratio of 1/4 to 1/3 sockeye produced by each brood year from 1908 to 1949, for the Skeena and Owikeno runs, but the age breakdown is based on samples from the catch only.

2.2. Area 3 (Nass)

In the Area 3 catches, both of the freshwater ages of sockeye have been well represented (Fig. 8). From 1912-15 to 1935-40 the 2-freshwater type was about 2.5 times as numerous as the 1-freshwater. Starting with 1941-45 a change began, slow at first but accelerating after 1961, so that in 1965-72 the 1-freshwater type was about 2.5 times as numerous as the 2-freshwater -- reversing the original situation. This may have to do with a possible change in the relative contribution to the catch by the two major lakes in the system.

Ocean ages among Area 3 sockeye catches have been mainly 4 for 1-freshwater fish and 3 for 2-freshwater fish, so that a total age of 5 at maturity has always been predominant. In spite of this, and unlike Areas 4 and 9, Area 3 has never had a dominant line that produced exceptional catches at 5-year intervals (Bilton et al. 1967, Table 2). Over the years the 1/3 life-history type has increased gradually, from about 10% in 1912-25 to 25% in 1965-72.

Because adult size depends mainly on duration of ocean life, we might have expected that the relative increase in the 4-ocean type from 20% to about 40% would be reflected in an increase in overall average size. But this did not occur; if anything, there has been a small decrease. There are two possible reasons, not mutually exclusive: (1) there may have been an increase in the percentage representation of lake stocks that are intrinsically slower-growing; (2) fishery selection may have reduced the mean size of the 3-ocean fish more than it has increased the size of the 4-ocean fish (see Section 6).

2.3. Area 4 (Skeena)

The Area 4 catches have always been dominated by the 1-freshwater type of sockeye (Fig. 9). Never more than 15% of the total, the 2-freshwater type gradually became less common after about 1930. This coincides with a decline in the relative contribution, to the total Skeena run, of several small lakes where 2-freshwater sockeye are a common type. Babine Lake, much the largest in the system, produces a great preponderance of 1-freshwater smolts.

Within the 1-freshwater group, there have been dramatic changes in the relative abundance of 3-ocean and 4-ocean sockeye. From approximate equality in the 1912-20 period, 3-ocean fish increased in relative numbers to 1935-40, declined abruptly during 1941-50, increased through 1955-60, and decreased somewhat subsequently. These changes were accompanied by two sequences of line dominance in the catch, well shown in Fig. 2 of Godfrey (1958). There were peak catches of 4-ocean fish at 5-year intervals in 1914-19-24, and similarly large catches of 3-ocean fish at 4-year intervals in 1936-40-44-48-52. However, the amplitude of these "cycles" was quite modest, especially in comparison with the original 4-year cycle on the Fraser. Details of Skeena catches and escapements are given by Milne (1955), Shepard and Withler (1958), Shepard et al. (1964), and Ricker and Smith (1975). Factors that may be involved in the changes include fishing seasons and techniques; the competition between year-classes described by Ricker and Smith

(1975); the Babine River slide in 1951 and 1952, which favoured the survival of 4-ocean fish (Godfrey et al. 1954); a greater percentage utilization of the 4-ocean sockeye, especially since 1950 (see below); and the spawning channels constructed on two tributaries of Babine lake during the 1960s. However, there is not enough detailed information from which to reconstruct the effects of these various factors quantitatively.

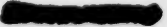
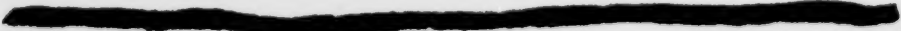
During the period 1964-69 age compositions (excluding age 1/2) are available for the Skeena escapement as well as the catch, based on test fishing above the commercial fishing boundary as reported by Bilton and colleagues. Table 8 brings these data together. (The percentages do not add to exactly 100 because very small numbers of other life-history types are omitted.) The 2-freshwater types are not numerous enough to form a consistent pattern in a short series, but among 1-freshwater sockeye the 3-ocean fish are in every case more numerous in the escapement than in the catch, while the 4-ocean fish are less numerous in the escapement. If all 3-ocean fish are compared with all 4-ocean fish, the 3-ocean increase by 9.0 percentage points, and the 4-ocean decrease by 9.4 points, from catch to escapement. During the years in question catch and escapement were approximately equal, so about 45% of the 3-ocean fish were caught, as compared with 54% of the 4-ocean.

The extra utilization of the older and larger sockeye became more intensive starting in the late 1940s. In 1945 the change was made from buying sockeye by the piece to buying by the pound. This made it advantageous for the gillnetters to use a slightly larger mesh, in order to increase their take of the larger fish and so increase the weight of their catch, and by about 1950 this change had probably been made by most fishermen.

2.4. Area 9 (Owikenno)

The Owikenno sockeye run has been dominated by 1-freshwater fish, in spite of the fact that its smolts are among the smallest known. The 2-freshwater contingent has always been less than 5% of the 5-year mean composition (Fig. 10).

The ratio of 3-ocean to 4-ocean types in the catch has fluctuated: 3-ocean fish rose to a maximum of 65% during 1925-30, declined to 40% in 1945-50, and varied erratically thereafter. The early superiority of 4-ocean fish was accompanied by 5-year line dominance peaking in 1915-20-25-30-35, the last two peaks being much smaller than the earlier ones (Godfrey 1958, Fig 1). By 1925-30 the 3-ocean fish had become the commoner type, and a 4-year line developed with peaks in 1937-41-45-49-53. However, 4-ocean fish increased again during 1945-55, and since then there has been no clear pattern, nor are there any proven explanations for the observed changes. Note that in both the 5-year and the 4-year sequences the Owikenno peaks occur 1 year later than those of the Skeena (Godfrey 1958, Fig. 3). Similarly, neither the Skeena nor the Owikenno 4-year sequence coincides with the present 4-year series of big years on the Fraser, which began in 1926.



3. CHANGES IN SIZE OF THE SOCKEYE CAUGHT

3.1. Long-term trends in the size indices

The first comprehensive summaries of changes in size of British Columbia sockeye were by Godfrey (1958) for the Owikeno and Skeena runs. Killick and Clemens (1963) dealt with the Fraser primarily, but to some extent also with the large northern runs; see especially the mean weight residuals in their Fig. 22-24 and 29.

Fig. 1-7 here show the fluctuations in the logarithmic size indices of sockeye sampled through the years. In most cases there is no consistent pattern. The most striking change has been the decrease in size of Nass's sockeye of the 2/3 and 2/4 types since about 1935 (Fig. 1). There is no decrease of comparable magnitude among Nass 1-freshwater types, although the 1/3s have fallen off somewhat (Fig. 2). On the Skeena the 4-ocean fish have increased in size while the 3-ocean type became smaller (Fig. 3, 4). The Owikeno 1/3s also decreased (Fig. 5). Fraser 1/3 sockeye exhibit no consistent change in size, either considering the run as a whole or the four lines individually (Fig. 6, 7).

3.2. Trends in the size indices since 1943

Because there are ocean temperature data starting in 1943-44, this period is of special interest. Fig. 11 shows the fluctuations in the logarithmic size indices in the 4 major populations, from 1944 to 1972 (1980 for the Fraser). Representing the index by Y and time in years by t (1940 = 0), the regression lines and correlation coefficients are as follows:

Nass:	$Y = 2.8027 - 0.0004102t$	$r = -0.505^{**}$	$N = 29$	(1944-72)
Skeena:	$Y = 2.7781 + 0.0002453t$	$r = +0.429^{*}$	$N = 28$	(1944-72)
Owikeno:	$Y = 2.7602 + 0.0001622t$	$r = +0.170$	$N = 29$	(1944-72)
Fraser:	$Y = 0.2629 - 0.0002211t$	$r = -0.164$	$N = 31$	(1944-74)

For Skeena and Owikeno the trend is positive, while for Nass and Fraser it is negative. Obviously trends in size during the period since 1943 are small, inconsistent as to direction, and much less striking than the variation between years. Residuals from the above regression lines are shown in Table 4, and are used for comparisons with ocean conditions.

In Area 3 the 2-freshwater types make the principal contribution to the significant decline in size of sockeye caught during this period (Fig. 8), although the 1/3 type also decreased slightly. Because they were less numerous than the 1-freshwater type, the 2-freshwater fish have a disproportionate influence on the index, which gives all 4 types equal weight. An index weighted by the abundance of each type would exhibit a much smaller rate of decrease.

On the Skeena the increase in the size index is significant at the 95% level, [REDACTED]. It was 0.0002453 base-10 log units per year, corresponding to a [REDACTED].

weight increase of about 0.17%/yr, which is 4.7% or about 0.3 lb during the 27-year period. Both the 3-ocean and the 4-ocean fish are involved in the increase. A possible contribution to this increase may have come from the Babine River slide, which both in 1951 and in 1952 blocked about two-thirds of the run to Babine Lake. The slide stopped more of the smaller fish than of the larger (Godfrey et al. 1954), so that for 2 years the larger fish of both ocean ages had an important reproductive advantage. However, the actual year-to-year changes in sockeye size in Fig. 3 and 4 give no clear indication of this effect. Presumably it is masked by environmental variability.

Size index changes in Area 9 during 1943-72 were weakly positive, and in Area 29 weakly negative, neither "significant".

3.3. Trends in mean weight during 1951-80

Fig. 12 shows the course of mean weights of sockeye caught in 4 major statistical Areas, from Table 6. The regression lines shown are for 1951-75 only, and it is clear that none differs significantly from zero. When smoothed, the data indicate fluctuations in size similar to those of the indices in Fig. 11: a rather sudden drop from large size in the early 1950s to a low in the early 1960s, followed by a gradual increase to about 1975 (Fig. 13).

Tables 9-11 give the 1951-75 regressions for all Areas with a significant catch. There are 11 cases of increase in size (3 of them "significant"), and 26 decreases (1 "significant"). Two of the significant increases are in Area 1, which has no local sockeye stocks of any consequence. Hence the increase there almost certainly resulted from a shift in the relative contributions of different stocks that pass through the Area: a stock or stocks whose sockeye were larger than the average size having become relatively more common. The same might apply to the single significant size increase in Area 7, although one or two such "significant" figures would be expected to occur by chance. In any event, neither Area 1 nor Area 7 is an important contributor to the total sockeye catch (Table 5).

At the foot of Table 6, and also in Fig. 12, are shown mean weights for 1976-80, which are not included in the regressions of Tables 9-11. These have no consistent trend in either direction.

3.4. Correlations between size of sockeye of different Areas

Godfrey (1958) compared the sequences of mean weights of Skeena and Owikeno sockeye of the 1-freshwater type over 39 years ending in 1952 or 1953. His Fig. 9 shows much similarity between these Areas in the trends for both males and females of both the 3-ocean and 4-ocean type. Correlations were all positive and lay between 0.477 and 0.611, all significant at the 99% level (Godfrey's Table 5).

Killick and Clemens (1963, Table 30) also obtained between-Area positive correlations for deviations of the weight of age 1/3 sockeye from the mean weight of each of the four lines of this life-history type, over a period of 39 years, as follows:

	Skeena	Owikeno	Fraser
Nass	+0.487**	+0.261	+0.232
Skeena		+0.567**	+0.026
Owikeno			+0.192

The three largest values above involve only the three northern Areas, whereas the three correlations involving the Fraser are all small and non-significant. For Killick and Clemens (1963, p. 99) "this strongly suggested that Fraser River sockeye were not reared in the same ocean environment as the northern runs and that presumably the Fraser sockeye would be located in a more southerly zone". However, Killick and Clemens' Fig. 29 shows that sockeye of age 1/3 in the northern runs (especially Skeena and Owikeno) decreased markedly in size during 1915-50, whereas the Fraser 1/3s had little trend; which difference accounts for the smallness of the correlations involving Fraser fish. But the decrease in size of the northern 1/3 sockeye is largely balanced by an increase in size of the 1/4s, both trends being a result of fishery selection as described in Section 6.2. Thus the small size of the three Fraser correlations in Killick and Clemens' Table 30 cannot serve as evidence for a different ocean distribution of the Fraser sockeye. And since 1963 the ocean tagging studies summarized by French et al. (1976) have shown that the distribution of sockeye from all regions of British Columbia and Alaska south and east of the Bering Sea is much the same during their penultimate year in the ocean (their Fig. 62, 63), and it is not greatly different even during their final year (Fig. 54-59).

Comparisons that include all important life-history types in each run are shown in Table 12, where the combined size indices of Tables 1-3 are used. There are 56 or 57 years compared, so the standard deviation of z is 0.14.¹ In this case the two correlations that are significantly different from zero both involve Fraser sockeye -- the reverse of Killick and Clemens' observation; and the Skeena-Owikeno correlation is small -- unlike Godfrey's results. But possible sampling error is large enough that we cannot be sure that any of the differences among these correlations are significant, although the fact that they are all positive is so.

The shorter sequence of 28-29 years in the middle panel of Table 12 gives larger correlations than the upper panel in all cases, the Skeena-Owikeno figure being now "significant". The standard deviation of z is 0.20, and again the entire set of 6 comparisons might be from a single statistical population. The generally larger r -values in this shorter series may merely reflect better sampling in more recent years, but it could also mean that there have been long-term changes in growth conditions, different for different rivers. Such effects might be, for example, changes in the relative abundance of different sockeye stocks within a river, or changes in the abundance of competing species.

¹ See Section 4.2 for the relation between z and the correlation coefficient r . When r is less than 0.4-0.5, r and $1/2$ are not much different, and the standard deviation of z , which is $(N - 3)^{1/2}$, can be used as a rough measure of the uncertainty in r .

Because the four shorter series all have trends with time (Section 3.2, Fig. 11), which in two cases are significant at the 95% level, comparisons were also made between the residuals from these trends in the lower panel of Table 12. These correlations are all positive and all "significant", and in general are larger than the correlations between the actual size indices. Again there are no significant differences among the six comparisons. The mean correlation, found by averaging the corresponding z values, is 0.521. The square of 0.521 is 0.272 or 27%, which is a minimum estimate of the contribution of oceanic conditions to the gross variability of the size indices in recent years.

Correlations were not computed for the weights in Table 6, but they have a similar pattern. Combining the evidence from the size indices, the mean commercial weights, and the correlations above, we obtain the following picture of the sequence of mean sockeye sizes in British Columbia during the recent period:

1944-49: small to average size
1950-54: large size
1955-61: small size
1962-72: variable but gradually increasing size
1973-80: variable size without significant trend

There are differences of a year, among the Areas, in the time each phase started, but the general agreement is excellent.

3.5. Relation between individual size and quantity of landings

In Table 13 the Table 6 figures for mean size of sockeye each year, in each of 5 Areas, are related to the Area's total landings obtained from Table 5. It shows that in years when landings are large the fish themselves tend to be large. It is possible that this could be a direct causal relationship involving growth rates: years in which growth was good might mean decreased predation because the young fish grew more quickly out of the size range attacked by any given predator; thus marine survival rate would be increased and hence also the number of fish that returned to meet the fishery. But it can equally be argued that a year of large numbers might make for small individual size because of competition for food among the members of the population.

A test for such effects can be made in Area 4 by comparing the size of the 1/3 and 1/4 sockeye in Table 2 of Ricker and Smith (1975) with the overall recruitment rate for the corresponding year-classes shown in the last column of their Table 1 -- but omitting the "slide" years 1951 and 1952. The correlations are +0.0030 for type 1/3 and -0.0017 for type 1/4, $N = 26$ in each case.

It is not surprising that the above correlations are both close to zero, considering the numerous factors affecting recruitment that are described by Ricker and Smith, and also the alternate-year effect mentioned in Section 7.2 below. But what then is the explanation of the significant correlations between fish size and total weight of landings in Table 13? For Areas 3, 4, 9, and 10 they are partly or wholly an "artificial" effect that does not involve any year-to-year variation in rate of growth. What is

required is (1) that there be two ocean ages of not too unequal abundance in each year-class; (2) that fish of the older ocean age average larger in size than those of the younger; and (3) that year-class abundance vary importantly. Simple numerical examples show that under these conditions there will be a positive correlation between the total weight of the catch and the mean size of the fish it contains, provided the older ocean age in the year-classes is (on average) more numerous than the younger, or only a little less numerous. (How much less depends on how much difference there is between the mean weight of the fish of the two ocean ages, and on how much difference in abundance there is between successive year-classes.) If the older ocean age in the year-classes is clearly more numerous than the younger, on the average, there will also be a positive correlation between mean fish size and the number of fish caught each year. This effect has been observed also in chum salmon data, and it was discussed in Section 5 of Ricker (1980).

In southern British Columbia, and particularly on the Fraser, the run and the catch have been dominated by the 1/3 life-history type, so the explanation above cannot apply. However, for many years the fluctuations in abundance of Fraser sockeye have been strongly influenced by the 4-year cycle of the Adams River and associated stocks, which from 1926 onward have had big year-classes at 4-year intervals in the 1902 line (Ricker 1950, IPSFC Annual Reports). Fig. 7 shows that the age 1/3 sockeye of this 4-year sequence have been substantially larger than those of the other three lines. Thus the concurrence of large size and large numbers at 4-year intervals produces the significant positive correlation of 0.547 in Table 13.

4. COMPARISONS OF GROWTH RATES OF DIFFERENT LIFE-HISTORY TYPES WITHIN A RUN

4.1. Factors causing similar size changes

Table 14 illustrates the time relationships among the commonest life-history types of sockeye in British Columbia. The "jacks" (age 1/2) have not been sampled for size so are omitted from the discussion below.

Factors that can affect the final size of different life-history types (in the same or different years) include the following:

(a) Same duration of ocean life. Length of stay in the ocean is the most obvious factor that can affect final size, hence one that must be controlled when assessing other possible factors. It may also include an independent genetic element, if there exist stocks that are predominantly of different ocean ages and also differ in intrinsic growth rate.

(b) Same duration of freshwater life. It is known that 2-freshwater smolts tend to be larger than 1-freshwater, which would give them an initial advantage in size. On the other hand, 2-freshwater smolts always grow more slowly (on the average) during their first lake year than do 1-freshwater smolts of the same stock and year-class, and this slowness is also a feature of their ocean growth; but the same need not necessarily apply to comparisons of the two freshwater ages from different lakes.

In addition to the direct effect of length of freshwater life on final size, it is possible that an observed effect will also have a component of inter-stock genetic difference. It is known that sockeye having two years of lake residence mostly come from different nursery lakes than those which have only one year. Different stocks in a river system are known to differ in rate of marine growth, either genetically or because of different ocean distributions. Hence if the 2-freshwater stocks in a system differ in growth rate from the 1-freshwater stocks for either of these reasons, it will be confounded with any direct effect of freshwater age.

(c) Migrate to sea in the same calendar year. If adult size depends critically upon estuarine or inshore ocean conditions during the first year of marine life, fish that go to sea in the same calendar year should tend to vary in size in the same way, regardless of their final ocean age. However, sockeye (other than jacks) that go to sea in the same year must spend at least three common years in the ocean, so the comparisons include that effect.

(d) Return from the sea in the same calendar year. These comparisons include the effect of 3 or 4 common years in the ocean, including the year of maturation.

(e) Return from the sea in adjacent calendar years. These comparisons show the effect of two or three common years in the ocean, not including the year of maturation.

4.2. Data and procedure

Length data are available for life-history types 1/3 and 1/4 at Owikeno, and for 1/3, 1/4, 2/3, and 2/4 at Skeena and Nass. The size indices used are simple means of the log indices (defined in Section 1.4) for males and females, and are shown in Table 1-3. These indices were then correlated between the different life-history types that returned from the sea in the same calendar year, and between all life-history types in adjacent years (Tables 15-17). Table 18 summarizes the data by combining similar comparisons for each river.

The tables show both correlation coefficient (r) and its transformation to $z = 0.5[\log(1 + r) - \log(1 - r)]$. The latter is used when correlations are averaged, and can also be used to test the significance of observed differences. Values of z are distributed approximately normally with variance $1/(N - 3)$, where N is the number of pairs of observations correlated (Fisher 1950). Since $N = 58$ in these correlations, the variance of z is 0.01818, and its standard error is 0.135. For conversions in the other direction, $r = (e^{2z} - 1)/(e^{2z} + 1)$.

Obviously the five categories (a)-(e) described in Section 4.1 are not wholly independent. There are 31 possible combinations of five things taken 1, 2, 3, 4 or 5 at a time, but the actual possibilities are much fewer. Categories (d) and (e) are directly incompatible, which excludes the eight combinations that contain (de). Table 14 indicates that combinations abcd, abce, abc, abd, bcd, and bd also are physically impossible. In addition, it turns out that combinations ab, ac, ad, bc, cd, a, b, and c cannot occur in same-year or adjacent-year comparisons without involving one or more of the

remaining categories. Thus from the original 31, the field is narrowed down to 9: abe, acd, bce, ae, bd, be, ce, d, and e. One additional feature to be considered is the number of years of common ocean life. In the comparisons tested this can be either 2, 3, or 4 years, and it is indicated in the tables by the corresponding numeral.

The effect of any one of the categories (a)-(e) above can best be assessed in comparisons where the remaining categories are identical, whether present or absent. For example, the effect of category (a) -- length of ocean life -- is indicated by comparing (say) correlations of type (abe2) with those of type (be2). This means that we are comparing fish of the same freshwater age (b), which returned from the sea in adjacent years (e), after spending 2 ocean years in common; but which neither went to sea nor returned from the sea in the same calendar year, as indicated by the absence of (c) and (d). The two correlations being compared differ only in respect to ocean age (a).

4.3. Comparison of correlations

(1) Correlations in Tables 15-17 are predominantly positive, and more than half exceed the conventional 95% level of confidence, which is about 0.24 for all comparisons.

(2) Correlations tend to be larger for the Nass River than for the Skeena, Owikeno being intermediate.

(3) Sockeye having the same duration of ocean life, i.e. comparisons that include (a), are more similar in size than those having different ocean ages. The best controlled comparisons are as follows:

	Nass	Skeena	Owikeno	Mean difference
	<u>z</u>	<u>z</u>	<u>z</u>	<u>z</u>
abe2	+0.620	+0.034	+0.308	+0.299
be2	+0.253	-0.126	-0.061	
ae2	+0.492	+0.055	-	+0.238
e2	+0.116	-0.046	-	
Mean (weighted)				+0.275

In all five situations the comparison that includes (a) has the greater correlation. The mean difference in z is 0.275, and the corresponding correlation is 0.269.

(4) Sockeye having the same duration of ocean life, i.e. comparisons that include (a), but which differ in respect to the number of ocean years spent in common, differ somewhat in degree of size resemblance, as follows:

	Nass <u>z</u>	Skeena <u>z</u>	Owikeno <u>z</u>	Mean difference <u>z</u>
acd4	+0.746	+0.906		
acd3	+0.833	+0.371		+0.224
abe3	+0.620	+0.412	+0.281	
abe2	+0.636	+0.034	+0.308	+0.112
ae3	+0.374	+0.372		
ae2	+0.492	+0.055		+0.100
Mean (weighted)				+0.141

In both the (acd4) and (acd3) situations the whole of the fish's ocean life takes place in the same calendar years. For the other two pairs of situations above, the fish have one non-identical calendar year in addition to the 3 or 2 years spent in common. In all three types of comparison the differences are not consistent between areas: on the Nass and Owikeno those with the smaller number of common ocean years are more alike, though to a non-significant degree; whereas on the Skeena the larger number of common years is favourable to resemblance in size, and by a substantial amount. This difference between the runs is curious, but it may be merely a result of sampling variability. On balance, the longer common ocean life is favourable, the average difference in z being +0.141.

(5) Sockeye having the same duration of freshwater life, i.e. comparisons that include (b), are somewhat more alike in size than those of different freshwater ages. The best controlled comparisons are as follows:

	Nass <u>z</u>	Skeena <u>z</u>	Mean difference <u>z</u>
bd3	+0.465	+0.283	
d3	+0.383	+0.218	+0.074
abe3	+0.620	+0.412	
ae3	+0.374	+0.372	+0.143
abe2	+0.636	+0.034	
ae2	+0.492	+0.055	+0.062
bce3	+0.307	+0.211	
ce3	+0.242	+0.092	+0.092
be2	+0.253	-0.126	
e2	+0.116	-0.046	+0.028
Mean			+0.080

In 8 out of 10 cases the comparison that includes (b) is the larger, though the difference in z is not usually very great, and averages only 0.080.

(6) There are no completely controlled comparisons to test whether having the same first year in the ocean is favourable, i.e. correlations that include (c). If we ignore differences in number of common ocean years (but retain the same total number of ocean years), the following comparisons are possible:

	Nass <u>z</u>	Skeena <u>z</u>	Owiken <u>z</u>	Mean difference <u>z</u>
bce3	+0.307	+0.211	+0.110	
be2	+0.253	-0.125	-0.061	+0.187
ce3	+0.242	+0.092	-	
e2	+0.116	-0.046	-	+0.132
Mean (weighted)				+0.165

In all five cases the combination of a common year of seaward migration and an extra year of common ocean life makes for greater similarity in size. This is true even at Nass and Owiken, where longer common ocean life, by itself, gave the smaller correlations.

On the average, however, we must compare the mean z for the above comparisons, 0.165, with the mean of 0.141 for an extra common ocean year. This leaves a very small and non-significant difference of 0.024 to represent the distinctive effect of the first ocean year.

(7) Similarly there are no completely controlled comparisons to test the effect of having the final year of ocean life in common, i.e. correlations including (d), but the following can be considered:

	Nass <u>z</u>	Skeena <u>z</u>	Owiken <u>z</u>	Mean difference <u>z</u>
bd3	+0.465	+0.283	+0.391	
be2	+0.253	-0.126	-0.061	+0.358
d3	+0.383	+0.218	-	
e2	+0.116	-0.046	-	+0.266
Mean (weighted)				+0.321

In all five cases the difference is in the expected direction, and is numerically fairly substantial. We can be sure that an extra year of common ocean life, if it includes the final year, makes the fish more alike in size. The average z for an extra common year, not including the first or last, was 0.141. Subtracting this from the mean 0.321 above gives $z = 0.180$, $r = 0.178$, as the estimate of the similarity due to having a common final year, as such.

4.4. Absolute estimate of the effects of ocean conditions

The means of the z-values in the first two groups of Table 18 (acd4 and acd3) are 0.826 and 0.602 (see comparison 4 of Section 4.3). The squares of the corresponding correlations show the fraction of the total variability accounted for by sockeye that have a common ocean life but differ in freshwater age, as shown below:

	<u>4-ocean sockeye</u>	<u>3-ocean sockeye</u>
z	0.826	0.602
r	0.678	0.538
r ²	0.460	0.290

If these fish had had the same length of freshwater life, they would have been slightly more similar; the square of the correlation 0.080, estimated in comparison 5 of Section 4.3, is 0.006, and this can be added to the r² figures above, giving 0.466 and 0.296 (mean 0.381).

To interpret these figures, note that if the above r² values had been equal to 1, we would conclude that ocean conditions accounted for all of the year-to-year variability in estimated size among sockeye of any given ocean and freshwater age. The r² values, however, average 0.38, so this is our estimate of the fraction of the total variance that can be ascribed to oceanic conditions.

However, the word total is important. Much of the total estimated variability must arise from random error and from the certainly less than perfect representativeness of the sampling process. An approximate estimate of this "noise" in the data can be had by calculating the variance of the difference between male and female sizes from year to year (for a given life-history type). This variance may to a minor degree be due to actual year-to-year variation in the ratio of the sizes of the two sexes, but must be mainly due to random error and to non-random sampling. Several computations indicate that the variance of the difference between the sexes is about 49% of the total variance in observed size, so the contribution from these sources of error might be put at about 45%. On this basis the contribution of ocean conditions to the true year-to-year variance in size is about $38/(100 - 45) = 69\%$.

Other factors that may contribute to the remaining variance include size trends that are not due to oceanic conditions, and year-to-year variations or trends in the relative numerical contribution of the different stocks that make up a run.

Note that the unadjusted figure for the effect of ocean conditions, 38%, is larger than the 27% estimate obtained in Section 3.4 from comparisons between runs. In the present Section the estimates are for single runs, which may be assumed to experience greater similarity of ocean conditions than two widely-separated runs, at least during part of their first ocean year.

4.5. Summary

The correlations indicate, firstly, that length of ocean life, as such, affects the final size achieved by sockeye -- something that was already evident from inspection of Fig. 1-5, which show that 4-ocean fish are larger than 3-ocean. Secondly, the correlations suggest that length of freshwater life (or associated genetic effects) have a small effect on final size, 2 years of freshwater life producing slightly larger adults than only one. Finally, what is of most interest, the correlations indicate that ocean conditions affect the growth of sockeye, in that the more calendar years of ocean life that are shared by two identical life-history types, the more they resemble each other in final size. The resemblance is probably greater if the first year of ocean life is included in the common group of years, and it is certainly greater if the last year of ocean life is included. It is greatest of all when all the ocean growth is in the same calendar years. From that situation we estimate that about 38% of the observed variance in size, or 69% of the true variance, can be ascribed to variability of the ocean environment.

5. SOCKEYE SIZE IN RELATION TO TEMPERATURE

5.1. Sockeye in the ocean environment

In Section 4.4 it was shown that most of the year-to-year variability in size of sockeye of a given life-history type reflects variations in their ocean environment¹. Consequently attempts have been made to relate size changes to two characteristics of the ocean environment for which data are available -- surface temperature and salinity.

Of the two factors just mentioned, temperature has provided some possible relationships that are described in the Sections to follow. However, attempts to relate annual mean coastal or pelagic surface salinity to sockeye size, either singly or in a multiple regression with temperature, produced coefficients which were variable in sign, and none of which were significant when the number of opportunities for "accidental" significance was taken into account. These salinity correlations and regressions will not be reported here. Additional tests might be made, perhaps using values for the growing season only, or extreme values, but the small range of variation in pelagic salinity suggests that it can be related to the size of salmon only indirectly, if at all.

¹Overall mean size of all the sockeye taken from a run by a given type of gear is also importantly influenced by differences in the percentage representation of different life-history types from year to year. In addition, differences in the places and times that the gear is used probably made a small contribution to variability, but the size trends among sockeye caught by different gears have been similar.

The principal temperature series used for comparison with salmon sizes is that taken of the surface water at Ocean Station P (50°N, 145°W), shown in Table 19 and Fig. 11. Killick and Clemens (1963, Table 31) used temperature averages for the period August through July at Station P, because this period ends at the approximate time the current year's sockeye would be leaving the ocean, and the same procedure has been adopted here.

Because the ocean temperatures have had a trend in one direction only, during the period since 1944, comparisons with unidirectional trends in salmon size cannot be credited with any causal significance unless supported by other evidence. Such evidence can come from year-to-year deviations from the trend that are mainly of either the same sign or of the opposite sign. Accordingly straight lines were fitted to the temperature series, and from each observation was subtracted the value on the trend line for the same year, to produce a series of residuals. The series most used are shown in Table 20. These residuals were compared with similar residuals from the trends of salmon sizes.

Table 19 includes temperatures at several coastal stations in addition to Station P (for their locations see Fig. 1 of Ricker 1981). None of the series in the table can be considered as definitive, although quite adequate for the present purpose. For one thing, they are simple means of monthly averages, without adjustment for the different lengths of different months. More important, in most cases two different compilations had to be used, which differed slightly in some of the entries where they overlapped. Finally, in 4 or 5 years of each series it was necessary to interpolate figures for missing months (if more than 2, the mean is in parentheses). This was done by reference to entries for preceding and following months and to the mean trend of seasonal temperatures, and obviously slightly different decisions would be possible. Presumably there were also interpolations of missing days in arriving at the monthly means. Thus the temperatures tabulated are not reliable to more than $\pm 0.1^{\circ}\text{C}$ at best, and in a few cases they may differ from reality by up to perhaps 0.5° . However, the natural variability in temperature between years is so much greater than these sources of error that the latter make only a minor contribution of "noise" to the data.

Although all the temperature trends in Table 19 are negative, that for the Amphitrite series is very close to zero. There is no obvious reason why it should be different, unless it has to do with the proximity of a large bay (Barkley Sound). Rather surprisingly, the strongly mixed cool waters at Race Rocks near Victoria have a negative trend not much smaller than that of Cape St. James or Langara, in spite of their much smaller seasonal range of temperatures and smaller year-to-year variability.

5.2. Size indices in relation to temperature at Station P (50°N, 145°W)

Fig. 11 compares the Station P annual mean (August through July) surface temperature with the size index of sockeye for the four major Areas. Correlations were computed between mean temperatures during the 12 months that end on July 31 of the year of return of the fish, also those for the preceding 12 months, for the 12 months before that, and for the mean of those three

periods (Table 21). All are negative. The 95% significance level for these comparisons is about 0.38¹.

Also shown are the correlations between temperature residuals and the residuals of size (observed size less the size computed from the regression of size on time). These too are negative and are numerically greater than the direct correlations when temperature and size have the same trend (Nass and Fraser), and are less (with one slight exception) when temperature and size have opposite trends (Skeena and Owikeno). This is according to expectation, because similar trends tend to produce positive correlations which decrease the magnitude of an inherent negative correlation, and increase a positive one.

The fact that all the correlations in Table 21 are of the same sign is not surprising in the light of the positive correlations between sockeye sizes in different Areas (Table 12). Correlations with the previous year's temperature are usually of the same order as for the current year; in fact are somewhat larger on the average. Correlations between sockeye size and temperature 2 years earlier are also of the same order of size, though on the average less than those for the previous year. This too could be a direct effect of temperature on growth during the first ocean year of 3-ocean fish, and during the second ocean year of 4-ocean fish. However there is a certain degree of serial correlation in the temperature series (Fig. 11), so the correlations in Table 21 are not completely independent.

It is of course true that none of the correlations in Table 21 are very large, absolutely, so Station P temperature is not a very good predictor of sockeye size. However, the methods of sampling used cannot have given a value for length or weight that is perfectly representative of a whole year's run, and the relative abundance of different stocks (having different mean sizes) within each run has changed from year to year (Fig. 8-10). Hence the true causal influence of temperature (or associated factors) on size must be considerably greater than is suggested by the squares of the r-values in Table 21.

For general predictive purposes a 3-year average temperature might be used. The last column of Table 21 shows the corresponding correlations, which are larger than most of those for the individual years. Values of r^2 for the residuals range from 15% to 34% (average 25% using the z-transformation). This is an estimate of the mean fraction of the residual variability in the size index that is related to the residuals from this combination of 3 years of temperatures.

¹ At a late stage an error was discovered in the August-through-July (1965-66) temperature at Station P. The incorrect value was included in the temperature series of Fig. 8 of Ricker (1981), but the correct figure had been used earlier (cf. Table 16 of Ricker et al. 1978). The error made the regression of temperature on time $-0.0258^\circ\text{C}/\text{yr}$ instead of the correct value -0.0282 , and the effect on the residuals varied from 0 in 1944 to 0.08°C in 1974. The correct value and its derivatives are used in Tables 19 and 20 and in Fig. 11 here, but the uncorrected figures were used for Tables 21 and 22, where the correlations involving Station P should be slightly larger, numerically.

5.3. Mean weight of sockeye caught in relation to ocean temperatures

Table 22 compares residuals of weight with residuals of mean August through July surface temperatures at Station P and three coastal stations, for series ending in the same year (S), the previous year (P) and the year before that (A). In central and northern British Columbia (Areas 9, 4 and 3) we expect these correlations to be smaller than those based on combinations of individual life-history types in Table 21, because year-to-year changes in the ratio of 3-ocean to 4-ocean fish introduce an additional important source of variability into the mean weights used in Table 22. This does not indicate, however, that the effect of temperature (or related factors) on size is any less in the north than it is for the Fraser run, where this source of variability is very small.

As it happens, things turn out according to expectation. The Fraser-Station-P negative correlations in the lower right corner of Table 22 are in fact quite similar to those on the last line of Table 21. In the other three Areas the Station-P correlations of Table 22 are all much weaker than those of Table 21; in fact two of the same-year figures are weakly positive.

The three coastal temperature stations produce very small positive same-year correlations, mostly negative penultimate year correlations, and strong and usually "significant" negative correlations in the antepenultimate year (Table 22). The overall picture is that cooler temperatures make for larger sockeye.

A quantitative estimate of this effect will be made for the Fraser run, which, as explained above, will be our best estimate for the whole coast. The estimated rates of decrease (GM regressions) corresponding to the three Fraser correlations with Station-P temperature residuals for 1951-74 (lower right of Table 22) are 0.95, 0.93 and 0.94 lb per degree Celsius, respectively, or 0.92 lb/°C on the average. The estimated rate of decrease in temperature at Station-P was 0.0184°C/yr for the years 1951-74; i.e. somewhat less than for the full period 1944-74 shown in Table 19. The product of these suggests a rate of increase in size of 0.0173 lb/yr, or 0.42 lb over the 24-year period. The reason that British Columbia sockeye did not in fact increase in size during 1951-74 is discussed in Section 6.1.

5.4. Reasons for the negative relationship between temperature and size of sockeye.

Why should the relation between sockeye growth and temperature in British Columbia be negative? Killick and Clemens (1963)¹, who originally observed this effect, suggest that "the sockeye do not remain in the area of Station P when the temperatures are warm; instead they seek a cold temperature which would place them in waters farther to the north. Thus, when the warm component of the North Pacific drift is dominant, the sockeye would be distributed to the northward where conditions for growth may not be the best. Conversely, when the cold component of the drift is dominant, the sockeye would occupy more southern latitudes where conditions for growth apparently are more favourable." I will designate this as the first

hypothesis. However, the idea that a sockeye's reaction to temperature could impel it to avoid the region most favourable for growth seems improbable on general evolutionary grounds. Natural selection should see to it that they inhabit the region where growth is best; unless, of course, it happened to be a region where survival was poor.

A second hypothesis is that the sockeye are in much the same place every year, but that cooler temperatures in fact favour more rapid sockeye growth in the Gulf of Alaska. The average surface temperature at Station P for the year has varied between 7.8° and 9.7°. The average for the warmest calendar month has varied from 11.6° to 14.7°. Brett et al. (1969, Fig. 11) found that sockeye in fresh water made best growth at 14°C when supplied with excess food, but if less food was available the temperature for maximum growth was lower. At about 70% of maximum ration best growth occurred at 12°, and at 40-45% of maximum it was 9.5°. How large a ration sockeye consume in nature is not known, but it is probably safe to assume that over the main growing season it averages considerably less than the physiological maximum ration. Thus growing-season temperatures less than the warmest may be favourable to sockeye growth under the temperature and food regimes that actually exist in the North Pacific; if so, the negative correlations are completely understandable.

The above situation exists even if food supply remains constant from year to year. However, a third hypothesis can be considered, that the principal factor causing variations in sockeye growth in the sea is not temperature, but some negatively correlated factor -- possibly food supply. In the latter event cooler temperatures would promote growth by increasing food supply. At present there are no data for examining this idea directly. If it were true, we might expect pink and chum salmon also to have significant negative correlations between Station P temperature residuals and their size residuals. In fact these correlations are mixed (Ricker et al. 1978, Ricker 1980); some are positive and some negative, although the Fraser pinks do have a non-significant negative correlation.

The direct correlations between size and temperature for the Skeena in Table 21 have larger negative values than those for the Nass. This is presumably because the Skeena size trend was positive (Section 3.2, Fig. 11) while the temperature trend was negative; whereas on the Nass the size trend was negative and so opposed any causal negative relation between size and

¹ Killick and Clemens (p. 101) obtained a correlation of -0.5334 between weight of Fraser sockeye in 1944-60 and the same year Station P temperature (1947-48 is excluded because temperature data were not available). For reasons unknown I get a somewhat smaller value, -0.446, using the same data. The correlation with logarithm of weight is very similar, -0.434. Using the whole series now available, 1944-74, the correlation with log weight has fallen to -0.058, which is numerically the smallest *r* in Table 21, presumably because temperature and size had similar downward trends over the period in question, which makes for a positive correlation. The correlation between residuals of the size index and of temperature is only slightly larger (-0.154). However, there are significant and near-significant correlations between residuals of size and residuals of temperature in the previous year and in the next earlier year, both in Table 21 and in Table 22.

temperature. When the correlations of residuals are compared in those two Areas, it turns out that both in Table 21 and in Table 22 the correlations are greater, in the negative direction, for the Nass than for Skeena, in almost all categories. (This is consistent with the larger correlations among life-history types that were found on the Nass). The reason is not obvious, for it seems unlikely that Nass sockeye should be more responsive than Skeena sockeye to the vicissitudes of the ocean environment. The two runs do differ in their coastal environment: Nass smolts reach salt water 70 km up Portland Inlet and must descend it before reaching the open ocean, whereas Skeena smolts have no comparable experience. However it is not obvious how this would make for a different response to ocean temperatures.

5.5. Temperature trends and trends in sockeye size

The analysis of Section 4.4 indicates that oceanographic conditions play the major role in causing year-to-year variations in size of sockeye of a given life-history type, at least in central and northern British Columbia. Residuals of ocean surface temperature, as measured at Station P, have a significant negative correlation with residuals of the sockeye size index in the four major Areas (Section 5.2), and negative correlations predominate between residuals of mean weight and of temperature (Section 5.3). Fig. 11 shows that ocean temperatures have decreased from 1944 to 1974; hence we might expect sockeye sizes to exhibit a corresponding trend upward during this period.

No such general increases are evident. Instead, the small net changes that occurred up to 1975 were mostly decreases (Tables 9-11, Fig. 11, 12). The only apparently significant increase, that for the Skeena size index, may have been a product of the proportionately larger destruction of the smaller sockeye at the Babine slide in 1951 and 1952.

6. EFFECTS OF THE FISHERY ON SIZE OF SOCKEYE

6.1. Changes in overall average size

The size differences between sockeye caught by different gears were indicated in Section 1.6. Like Killick and Clemens (1963, p. 104), I have considered seines to be an unselective gear for sockeye of ocean ages 3 and 4, so that both trolls and gillnets have been preferentially cropping the larger fish, at least since 1950 (Table 6; summary in Table 7). For the Skeena gillnet fishery this is also indicated by the greater proportion of 4-ocean sockeye in the catch than in the escapement (Section 2.3), and by Todd and Larkin's (1971) size comparisons between catch and escapement.

In the case of gillnetting this selectivity for the larger fish has been mainly a matter of the mesh size used in the nets. Partly, however, it is an indirect effect of sexual selection determined by the seasonal pattern of fishing and the fact that in nearly all stocks males are larger than females of the same ocean age. There has been a natural and almost

unavoidable tendency to allow fishing to proceed at a normal pace early in the season until a good idea of the total abundance of the run was obtained, then apply such restrictions as were needed to permit an adequate escapement. In fact, prior to about 1945, the only fishing closure apart from Sundays was for a week or so in early fall, during which interval much of the season's escapement went upriver. The most important result was that stocks which entered the fishing grounds in the latter part of the season were favoured for reproduction. But in addition, in stocks that benefitted from the autumn closure, the females usually benefitted more than the males because in each stock males tend to run earlier than females. This effect has become less important since the 1940s, because concerted efforts are now made to obtain the most appropriate escapement for all important stocks in each river.

In view of the selectivity of both of the types described above, we might have anticipated that sockeye would have decreased importantly in size, especially after 1945 when buying by weight made larger fish more valuable than smaller ones. In fact, however, the decreases in sockeye size have been small (Tables 9-11, Fig. 1-7, 11, 12). This contrasts sharply with the situation for pink and coho salmon, both of which have suffered major decreases in size since 1950 without any change in age structure (Ricker et al. 1978; Ricker and Wickett 1981).

The mean trend in sockeye size during 1951-75, such as it is, has been downward. To examine this more closely, it is necessary to treat the northern and central (N-C) Areas 1-11 separately from the southern Areas 12-27 which are dominated by the Fraser run. In Areas 1-11 gillnetting has always been the principal method of taking sockeye. The weighted mean difference in weight between gillnetted and seined sockeye is 0.59 lb (Table 7), which provides a basis for strong selectivity favouring the survival of the smaller fish. In spite of this, over 24 years the N-C seined fish decreased in size by a weighted mean value of only 0.21 lb (Table 10), and the gillnetted fish by 0.18 lb (Table 9) both of which are small and non-significant changes. However, the fact that the N-C catches include two important ocean ages introduces a complication similar to that described for chum salmon (Ricker 1980). The 4-ocean sockeye are larger than the 3-ocean, but they grow more slowly (Ricker 1962, 1976). Hence selection that favours the survival of more of the smaller fish for the spawning stock also favours faster growth, and the net effect on overall mean size is unpredictable.

The southern region (Areas 12-29) differs in several ways from the northern and central. For one thing, it is dominated by the run to a single river, the Fraser, whose sockeye can be found in all the Areas, although they are mixed with a number of local runs, especially along the coasts of Vancouver Island from Areas 22 and 13 northward. Another difference is that the catch from the southern runs has included a much larger proportion of seined fish. Gillnets do predominate in the Canadian fishery (Table 5), but there is an equally large United States fishery that attacks the same stocks, mainly of Fraser fish, and which up to recently was mainly by seining and (before 1935) by traps (Rounsefell and Kelez 1938, IPSFC Annual Reports). A third difference is that the gillnets in Areas 12-27 have been less selective for large fish than the N-C ones, perhaps because size variability in the run is smaller. The smaller selectivity is shown by the fact that during 1951-75 the mean weight of sockeye caught by gillnet was only 0.17 lb greater than those taken by seine -- as compared with 0.59 lb in Areas 1-11 (Table 7).

For both of the above reasons the intensity of selection by southern gillnets has been much less than in the north. Nevertheless, during 1951-75 the size of southern sockeye decreased more rapidly: by 0.43 lb in the seine catch and by 0.38 lb in the gillnet catch, as compared with 0.21 and 0.18 lb in the north (Table 9, 10). The paradox is explained by the fact that sockeye of Areas 12-29 are dominated by 3-ocean fish to such an extent that the 4-ocean individuals play no significant role in the selection process. Thus the effect of a greater rate of harvest of the larger sockeye has not been opposed by a concomitant genetic increase in growth rate to any appreciable extent.

A word needs to be said about the possible role of "jack" or 2-ocean sockeye (age 1/2, rarely 2/2), which have increased greatly in the Birkenhead stock on the Fraser and in the Babine stocks on the Skeena (Ricker 1972). Jacks are usually only lightly fished, are almost entirely males, and their average growth rate is greater than that of later-maturing males. Their existence has two effects upon size in the commercial stocks. On the one hand some sockeye, that would otherwise mature and become available to the various fisheries as 3-ocean individuals, mature at the much smaller 2-ocean size; and insofar as these can be captured (mainly by seines), they decrease overall average size in the catch. This transfer of individuals to the 2-ocean group also decreases average size among the 3-ocean fish themselves, by removing faster-growing individuals from that category. On the other hand, insofar as they contribute genes favouring fast growth to the population's heredity, the increase in number of jacks may make for larger size at all ages in subsequent generations.

An effect that has presumably retarded the rate of decrease in size of sockeye everywhere is the negative correlation between size and temperature. In Section 5.3 we estimated that, for the Fraser sockeye, the cooling trend in the ocean should have permitted an increase in weight of 0.42 lb during 1951-75. In fact, the Fraser sockeye decreased in weight by an estimated 0.66 lb -- using the figure for Area 20 seines in Table 10, said by Killick and Clemens (1963) to be representative of the run before fishing. Without the cooler temperatures, southern sockeye would have decreased by an estimated $0.66 + 0.42 = 1.08$ lb or 490 grams.

6.2. Changes in relative size of 3-ocean and 4-ocean sockeye

Foskett (1958) compared the fork lengths of different ocean ages of 1-freshwater sockeye in the 1952 Area 9 gillnet catch with samples from the spawning grounds in tributaries of Owikeno Lake. His figures 6 and 8 are the comparison for males and females, respectively, while in his figure 7 there is an adjustment for the increase in male snout length at maturity (Fig. 14 here). Fig. 14 shows clearly that the larger of the 1/4 males and the smaller of the 1/3 males were less intensively harvested than those closer to the overall median size. The same is true of 1/4 females (Foskett's Fig. 8), but because the Owikeno 1/3 females were somewhat larger than the 1/3 males (Foskett's Fig. 3 and 5), they were closer to the median size and experienced little selectivity; if anything, the female 1/3 spawners were slightly larger than the catch (Foskett's Fig. 8). In the Nass and Skeena runs, where males

are larger than females in all life-history categories, the 1/4 males and 1/3 females would usually be less intensively utilized than the 1/4 females and 1/3 males. But in all Areas, within each sex of each life-history type, there is selective pressure favouring survival of individuals farthest from the size corresponding to the maximum fishing power of the nets and procedure used; which size, since about 1950, has evidently been a little larger than the overall median size of the fish. Jacks (age 1/2) are of course excluded from the statements above because they are smaller than the normal range of sizes caught by gillnet (Fig. 14).

It is known that rate of growth in salmon stocks can be changed by selection, so it is predictable that this situation should affect the mean sizes of the different sex-and-life-history categories of sockeye over a period of generations. This has in fact been observed. Godfrey (1958) examined this question in the samples from the runs of Areas 4 and 9 (Skeena and Owikeno) for the year-classes 1912-49. He found that 1/3 fish had gradually become smaller and 1/4 fish had become larger. Particularly striking were his figures 10 and 11, showing the difference in size (both length and weight) between sockeye of the same year-class and freshwater age but of different ocean ages. In every case the difference increased over the years, by 500 to 800 grams in all.

The top panels of Fig. 15-17 extend Godfrey's work up to 1972, and add Area 3, using lengths obtained and summarized by Bilton, Jenkinson and co-workers. In addition to their own 1956-72 samples, these authors converted the earlier lengths to the postorbital-hypural measurement. Figures 15-17 differ from Godfrey's figures in that the upper lines compare sockeye of the same freshwater age and the same year of maturity, averaged by 5-year intervals. This makes for somewhat better comparisons, because there is greater resemblance between the sizes of maturing sockeye taken in the same calendar year than between those of the same year-class (Section 4).

Figures 15-17 confirm that in all three Areas the difference in size between sockeye of different ocean ages increased up to 1950-54. Since then the difference has continued to increase at Skeena and Nass, but has apparently become stabilized at Owikeno. At Nass and Skeena the 2-freshwater sockeye have increased the size difference between the two ocean ages somewhat more rapidly than the 1-freshwater.

The size difference has always increased less among females than among males, but the 5-year variations in Fig. 15-17 (and the year-to-year variations in the original tables) tend to be similar between males and females. There is also some agreement among the Areas during the same time period. For example, there is a maximum difference in 1951-55, strongly expressed at Owikeno and Skeena, less so at Nass; and there is a dip in 1956-60, very marked for Nass and for Skeena 2-freshwater individuals, but less important at Owikeno where the 1961-65 interval is a low.

In summary, an important result of gillnet selection has been to increase the variability in size of sockeye in the major runs of the northern and central coast. The 4-ocean fish have become larger and the 3-ocean fish have become smaller, although at different rates as between males and females, and between 1-freshwater and 2-freshwater individuals.

6.3. Changes in relative size of the sexes

In Fig. 1-5 it is evident that sometimes the difference in measured size of the two sexes increased, sometimes it decreased, and sometimes there was little if any change. These trends are more clearly illustrated in the lower panels of Fig. 15-17, from which a synopsis of trends in the difference can be made as follows:

Increase: Nass 2/4; Skeena 1/4, 2/4; Owikeno 1/3

Decrease: Skeena 1/3, 2/3

Little or no change: Nass 1/3, 1/4, 2/3

It might be suggestive that the increases were (except Owikeno) among 4-ocean fish, and the decreases among the 3-ocean type; however, the increases of the 2/4 type at Nass and Skeena are only marginal, certainly not significant statistically. The Owikeno 1/3 increase is unique in that the males became smaller than the females.

Why should the size difference between the sexes have become altered? As noted earlier, the gillnet fishery concentrates on intermediate sizes in the total run. Thus it typically takes a larger fraction of the 4-ocean females than of the 4-ocean males, and a larger fraction of the 3-ocean males than of the 3-ocean females. If the phenotypic effects of the genes affecting size are to some degree sex-limited (and the fact that the sexes differ in size suggests that they are), the result of this selection could be a gradual genetically-determined change in the magnitude of the size difference between the sexes. It turns out that such a change can be in the direction of either an increase or a decrease in the difference!

Consider the 4-ocean sockeye, having males larger than females. In one extreme situation, which can be called Scenario 1, the females would all be completely vulnerable to the nets, while the larger of the males were less so. Then if genes controlling size were completely sex-limited, the males would gradually increase in size, while the females remained the same size; or if sex-limitation were incomplete, they would increase more slowly than the males. In either case the size difference between the sexes would increase. The other extreme situation, Scenario 2, is where the males would be too large to be caught at all, while the smaller of the females were completely vulnerable but the larger ones less so. Then the females would increase in size, while the males either remained unchanged or increased less rapidly than the females. Thus the size difference between the sexes would diminish. The same two scenarios can be applied to the 3-ocean sockeye by making appropriate modifications of the above.

Neither of the above scenarios is realistic, because male and female sockeye sizes always overlap quite broadly. However, they illustrate that the direction of this effect of gillnet selection will depend on details of the variation in the nets' catching power for fish of different sizes, on details of the size distribution of the male and female fish of each life-history type, and on the relative abundance of the 3-ocean and 4-ocean fish. And in fact a variety of reactions is indicated in the schedule above.

The increase in size difference between male and female Owikeno 1/3 sockeye is remarkable for the fact that there seems to be nothing for

selection to work on. From 1912 to 1950 the two sexes differed extremely little in mean size (Fig. 17); how then could selection operate? The answer presumably lies in the fact that males tend to enter the fishing area earlier than females, so were usually exposed to a greater rate of exploitation than the females (Section 6.1); thus they suffered more severely from whatever type of selection was in progress. For 3-ocean fish this was selection favouring reproduction of the fish of smaller size, and the males would consequently decrease in size more rapidly than the females if heritability of size is at least partly sex-limited.

7. COMPARISON OF SOCKEYE WITH OTHER SPECIES OF SALMON

7.1. Chum salmon

In Section 4.4 it was estimated that up to about 38% of the variability in observed size of sockeye from year to year could be ascribed to conditions of life in the ocean (including estuaries). It would seem reasonable, then, that there should be some year-to-year agreement in respect to observed size between sockeye and other species of salmon, especially pink and chum salmon which have similar, although not identical, ocean distributions and food habits. Comparisons can be made between the mean sockeye sizes in Table 6 and those of the other 4 species in the corresponding tables in FRBC Technical Reports 820, 930, 944, and 971. For convenience, several series of sockeye and chum salmon sizes are brought together in Table 23. When these and other series are plotted, they indicate only quite weak relationships, most of which are non-significant individually, but taken together they indicate the expected positive relationship.

Considering that the sockeye and chums in Table 23 have had at least 3 ocean growing seasons in common, including the last, it may seem surprising that the agreement is not closer. However, there are differences in the distribution and food habits of the two species. More important, probably, are differences in age structure. A major cause of the year-to-year fluctuations in size of chums and of the northern and central sockeye are the varying proportions of the 2 or 3 different ocean ages that appear in a run in successive years, as year-classes vary in abundance. But because the year-class strengths vary differently in the two species, this makes for poor agreement in overall mean size from year to year. Among southern sockeye there is only one important ocean age, but a different source of variability in size exists: the congenital differences in growth rate that characterize the major stocks that contribute to each of the four lines; and this too bears no relation to the year-class variability of the chum salmon.

7.2. Pink salmon

Table 24 compares sizes of sockeye and pink salmon taken in the same years in a number of Areas. Alternate years are listed separately because pinks are everywhere smaller in even-numbered years than in odd. Again the

corresponding graphs indicate only weak relationships, usually non-significant individually, but nearly always positive. To some extent they are influenced by the fact that both species have decreased in size during 1951-80, but the percentage decrease has been much larger among pinks than among sockeye.

However, there has been speculation that, at least in southern British Columbia, pink and sockeye salmon may make up a combined feeding unit large enough to affect the growth of both species, but particularly the sockeye. This was suggested by the fact that from 1925 to 1946, and again from 1952 through 1959, there was a steady alternation in Fraser sockeye sizes: larger in even years, smaller in odd years (Fig. 6). It was natural to suspect an effect of competition with Fraser pinks, because historically these have been numerous in odd years, and always practically absent in even years. The interruption of the alternation between 1947 and 1951 might be ascribed partly to the rapid changes in relative abundance of the various Fraser sockeye stocks caused by construction of the Hell's Gate fishways and the closure of early-season fishing during 1946-50; and partly to a sudden upsurge in size of sockeye, presumably because of favourable oceanic conditions, that occurred also at Owikeno and to a less extent northward (Fig. 11). Similarly the disappearance of the alternation after 1959 could be because southern pinks had at that time become greatly reduced in numbers and hence were no longer serious competitors.

While the above picture seems reasonably consistent, this "pink salmon effect", as an important influence on sockeye growth, was disposed of by Killick and Clemens (1963). In their Fig. 16 they showed that there was no regular alternation in the size of sockeye of the Chilko run during 1938-61; and also (Fig. 15) that within the odd years sockeye and pink sizes did not vary together (see Areas 20 and 29AB in Table 24 here). Killick and Clemens also called attention to the fact that sockeye of the 1901 line have been considerably smaller than the other lines from 1917 onward (Fig. 7) -- that is, both during a period of low abundance and during their increase in the 1950s and later, implying that the stocks that predominate in this line may be smaller than average by heredity. Because this is an odd-year line, this could account for half of the apparent agreement with the pink cycle. These and other considerations led Killick and Clemens to conclude that "the occurrence of lower annual average sockeye weights in 'odd' years must stem from some other reason than the suspected influence of 'odd' year pink salmon populations". They go on to present evidence that the sockeye stocks which make an important contribution to the odd year lines are, on the average, hereditarily smaller than those that predominate in the even year lines (see Fig. 7 here).

To the above we may add the following observation. The sockeye sampled in 1913, the last of the old "big" years of the 1901 line, were somewhat larger than those sampled from the same line in 1917 when abundance had fallen precipitously. The mean fork lengths were 613 mm in 1913 and 606 mm in 1917. The 1913 sockeye had to meet the competition not only of their own very numerous siblings (at least 30 million were caught), but also of a huge pink salmon run -- which can be estimated as of the order of 50 to 100 million fish by comparison of the Point Roberts trap catches before and after 1914, as tabulated by Rounsefell and Kelez (1938). If competition on this scale failed to depress sockeye sizes detectably, there seems little chance that the much smaller runs of both species in recent years could have had a noticeable effect on their rate of growth.

In most rivers from the middle of Vancouver Island northward pink salmon are more abundant in even-numbered years. There is no corresponding consistent alternation of sockeye sizes anywhere in the northern and central regions (Fig. 1-5). There was a short sequence of 2-year peaks for some of the Skeena life-history types during the 1930s (Fig. 3, 4), but the larger sockeye were in the even years when pinks were more numerous.

There remains the possibility that there might be significant competition between pinks and sockeye during the first ocean year of both, when pinks are at first smaller than sockeye but after a time rival or even exceed them in size. The idea is given some plausibility by Fig. 4 of the 1979 Annual Report of IPSFC, which shows an inverse relationship between mean weight and abundance of Fraser pinks in the odd years 1959-1979; the weights used being very close to those for Area 20 seined pinks shown in Table 24 here. If this relationship is a result of intraspecific competition, perhaps the sockeye that go to sea in the same (even) years could also be affected. Hence it is of interest to compare adult weights of pinks and sockeye that have had a common first year in the ocean. This means comparing pinks of year n with 3-ocean sockeye of year $n + 1$.

Table 25 shows that there is in fact a rather large positive correlation between the mean weights of the pinks of 1953-79 and the sockeye of 1954-80 in the catches of Areas 20 and 29, both of which consist largely of Fraser fish. Some part of this correlation may result from the similar downward trends in size, shown in Table 25, which may have had other causes. However, when deviations from the two linear regressions were compared for Area 20, the correlation decreased only from 0.694 to about 0.65, showing that most of the agreement comes from year-to-year resemblance in size rather than the common trend. Sockeye in other Areas, however, give no suggestion of this effect. Direct comparison of pink sizes in the more northern runs with the size of sockeye of the same seaward-migrating year is impossible with the data of Table 6, because there the adult mean weights of sockeye include two important ocean ages. However, comparisons were made of pink sizes in the catch data (Table 4 of Ricker et al. 1978) for the years 1951-71 with age 1/3 and 2/3 sockeye size indices for 1952-72 (Tables 1-3 here). These all indicated very weak and non-significant relationships, which were negative as often as positive.

This absence of relationship in the three more northern runs suggests that the Fraser correlations might be accidental, in spite of their statistical significance when considered alone. However, assuming they mean something, they might have one or both of two causes: (1) interspecific and intraspecific competition may reduce the size of both pinks and sockeye when pinks are numerous; and (2) growth of both species may benefit from the same favourable conditions, particularly in the southern straits, during their first ocean season, or suffer from the same unfavourable conditions -- independently of the abundance of either. The first possibility involves the anomaly that while it requires that the less numerous of the odd-year pink stocks reduce competition and so produce large sockeye (and pinks), and vice versa, yet no pinks at all (practically) in the even spawning years produce small sockeye of the same seaward-migrating generation, as shown by the generally small sockeye sizes in the odd years of Fig. 7. Although this can be ascribed, partly at least, to hereditarily slower growth of the sockeye of

the odd year-classes, possibility (2) above is to be favored because of the considerations outlined near the beginning of this Section.

Summarizing, it is only on the Fraser that there is evidence for any important influence of a common first year of marine life on final size of pinks and sockeye. Further, the agreement, if it is really significant, probably results from their experiencing similar physical or biological conditions during that year, rather than its being a function of the abundance of the pink population. This in turn suggests the possibility that the inverse relation between size of pinks and their own abundance may also be at least partly coincidental. Since 1959 restraint of fishing has put the Fraser pink run on the road to restoration of a former higher level of abundance, and this increase has happened to coincide with a decrease in individual size caused mainly by many years of selective harvesting of the larger individuals (Ricker et al. 1978).

Although it is only marginally related to the present study, there has recently been a marked alternation in marine survival rate of Area 4 sockeye at all levels of smolt production except the largest (Peterman 1978, Fig. 5). For the brood years 1956-69 the geometric mean percentage return of Babine yearling smolts was 2.3 times as great in odd years as in even (compare column 13 of Table 1 with column 10 of Table 2 in Ricker and Smith 1975); and there is no consistent superiority of smolt size in the odd years that might account for it. The smaller survival rate in even years cannot result from greater competition for food with young pink salmon, because in most northern Areas and in adjacent Alaska pink fingerlings are much more numerous in odd years, being progeny of the abundant even-year runs. (In recent years pinks have been of more or less equal mean abundance in odd and even years in Areas 3 and 4, but in adjacent Areas 1, 5, 6 and nearby Alaska even years have several times as many pinks as odd -- see Tables 1 and 2 of Ricker et al. 1978.) A possible reason for the poorer even-year survival of Skeena sockeye since 1956 is that on their way out to the open sea they experience greater predation from adult pink salmon returning to northern British Columbia and southern Alaska. Yet if pink salmon predation is so important, it is difficult to understand how a dominant sockeye line, with a large survival rate from spawners to recruits, could have flourished on the Skeena in the even brood years 1932-36-40-44-48.

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Sampling of the British Columbia salmon catches for age and size was begun in 1912 under the auspices of the Provincial Commissioner of Fisheries, the scales being read and reports prepared by Dr. C. H. Gilbert of Stanford University from that year through 1924. But if one man more than another should be given credit for making the present study possible, it is Dr. W. A. Clemens. From 1925 to 1948, while Director of the Pacific Biological Station and later Head of the Department of Zoology of the University of British Columbia, he continued the study begun by Dr. Gilbert and prepared an annual report on the age, sex, length and weight of the fish

in each sample. His wife, Dr. Lucy Smith Clemens, assisted with the work until her untimely death. In addition to the annual tabulations, Dr. Clemens published a summary review in 1935.

Following Dr. Clemens, this work was continued at the Biological Station for 8 years by D. R. Foskett. It was then incorporated into a more comprehensive sampling program by H. T. Bilton, D. W. Jenkinson and their colleagues, but this was unfortunately discontinued after 1972. Meanwhile Dr. Clemens, after retiring at the University, undertook with S. R. Killick of the International Pacific Salmon Fisheries Commission a comprehensive study of seasonal and year-to-year changes in the biological characteristics of the Fraser sockeye run as a whole, and of its component lines and stocks, which was published in 1963.

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Table 1. Nass sockeye: base-10 logarithms of fork length in decimeters for four life-history types, males and females being given equal weight.

	1/3	2/3	1/4	2/4	Mean		1/3	2/3	1/4	2/4	Mean
1912	.7711	.8018	.8044	.8129	.7976	1941	.7813	.8010	.8129	.8337	.8072
1913	.7684	.8010	.7940	.8131	.7941	1942	.7768	.7961	.8113	.8272	.8029
1914	.7653	.8062	.8010	.8121	.7962	1943	.7570	.7814	.8104	.8272	.7940
1915	.7685	.8114	.8001	.8070	.7968	1944	.7684	.7904	.8053	.8248	.7972
						1945	.7684	.7913	.7975	.8080	.7913
1916	.7702	.8086	.8026	.8211	.8006	1946	.7646	.7921	.8129	.8367	.8016
1917	.7590	.7904	.7922	.8079	.7873	1947	.7694	.7859	.8025	.8247	.7956
1918	.7841	.7983	.7939	.8111	.7969	1948	.7656	.7949	.8156	.8393	.8039
1919	.7813	.8105	.8027	.8296	.8060	1949	.7721	.7886	.8023	.8165	.7949
1920	.7666	.8130	.8018	.8188	.8001	1950	.7731	.7868	.8087	.8222	.7977
1921	.7703	.8062	.7885	.8254	.7976	1951	.7767	.7957	.8112	.8345	.8045
1922	.7684	.7966	.7921	.8236	.7952	1952	.7758	.7913	.8205	.8353	.8057
1923	.7722	.8054	.8010	.8223	.8002	1953	.7740	.7940	.8239	.8377	.8074
1924	.7767	.8053	.8000	.8193	.8003	1954	.7777	.8010	.8181	.8336	.8076
1925	.7740	.7983	.7956	.8103	.7946	1955	.7607	.7786	.8087	.8196	.7919
1926	.7813	.8028	.8028	.8321	.8048	1956	.7694	.7841	.8027	.8181	.7936
1927	.7823	.8097	.7949	.8256	.8031	1957	.7608	.7886	.8001	.8070	.7891
1928	.7703	.7913	.8001	.8270	.7972	1958	.7705	.7855	.8012	.8045	.7904
1929	.7684	.7974	.8019	.8198	.7969	1959	.7673	.7754	.7975	.8033	.7859
1930	.7740	.8053	.8070	.8305	.8042	1960	.7573	.7771	.7824	.7995	.7791
1931	.7749	.8028	.8097	.8431	.8076	1961	.7633	.7759	.7970	.7911	.7818
1932	.7703	.8096	.8044	.8438	.8070	1962	.7619	.7718	.8087	.8180	.7901
1933	.7749	.8044	.8155	.8434	.8096	1963	.7610	.7710	.8037	.8090	.7862
1934	.7813	.8053	.8147	.8384	.8099	1964	.7508	.7864	.8056	.8144	.7893
1935	.7804	.8053	.8180	.8449	.8122	1965	.7694	.7864	.7978	.8220	.7939
1936	.7813	.8096	.8130	.8362	.8100	1966	.7594	.7747	.8089	.8037	.7867
1937	.7637	.7832	.7947	.8206	.8056	1967	.7616	.7771	.8103	.8145	.7909
1938	.7684	.7868	.7975	.8139	.7917	1968	.7626	.7890	.8120	.8132	.7942
1939	.7823	.8028	.8138	.8288	.8069	1969	.7644	.7880	.8084	.8143	.7938
1940	.7921	.8189	.8329	.8519	.8240	1970	.7634	.7737	.8111	.8046	.7882
						1971	.7582	.7813	.8021	.8170	.7897
						1972	.7672	.7885	.8080	.8255	.7973

Table 2. Skeena sockeye: base-10 logarithms of fork length in decimeters for four life-history types, males and females being given equal weight.

	1/3	2/3	1/4	2/4	Mean		1/3	2/3	1/4	2/4	Mean
						1941	.7570	.7655	.8027	.7992	.7811
1912	.7730		.8044		.7887	1942	.7560	.7833	.7983	.8129	.7876
1913	.7570		.7921		.7746	1943	.7453	.7656	.7939	.8070	.7780
1914	.7684		.8018		.7851	1944	.7482	.7492	.7913	.7912	.7700
1915	.7694	.7712	.7983	.7907	.7824	1945	.7560	.7656	.7940	.7966	.7781
						1946	.7541	.7768	.8001	.8018	.7832
1916	.7675	.7712	.8009	.7992	.7847	1947	.7502	.7609	.7930	.8207	.7812
1917	.7609	.7694	.7922	.7940	.7791	1948	.7596	.7579	.7975	.8069	.7805
1918	.7665	.7656	.7983	.7895	.7800	1949	.7541	.7617	.8010	.7913	.7770
1919	.7693	.7693	.7949	.7978	.7801	1950	.7580	.7786	.8035	.8009	.7853
1920	.7627	.7675	.8036	.8018	.7839						
						1951	.7599	.7712	.8087	.8078	.7869
1921	.7618	.7684	.7850	.7823	.7744	1952	.7656	.7666	.8070	.8087	.7870
1922	.7609	.7637	.7877	.7786	.7727	1953	.7666	.7712	.8130	.8156	.7916
1923	.7609	.7637	.7904	.7903	.7763	1954	.7532	.7740	.8180	.8137	.7897
1924	.7665	.7749	.8027	.7957	.7850	1955	.7531	.7627	.8036	.7956	.7788
1925	.7570	.7665	.7930	.7957	.7781						
						1956	.7712	.7796	.8113	.7989	.7902
1926	.7647	.7758	.7940	.7992	.7834	1957	.7561	.7722	.8001	.7973	.7814
1927	.7646	.7684	.7949	.7913	.7798	1958	.7596	.7655	.8045	-	.7765
1928	.7541	.7560	.7904	.7930	.7734	1959	.7460	.7664	.7970	.7962	.7764
1929	.7493	.7588	.7922	.7885	.7722	1960	.7503	.7664	.7920	.7987	.7769
1930	.7512	.7521	.7777	.7701	.7628						
						1961	.7656	.7646	.7923	.7932	.7789
1931	.7590	.7618	.7949	.7948	.7776	1962	.7578	.7701	.8070	.8073	.7856
1932	.7541	.7616	.7868	.7886	.7728	1963	.7642	.7642	.8156	.8099	.7885
1933	.7531	.7693	.8019	.8053	.7824	1964	.7502	.7697	.8044	.7954	.7799
1934	.7627	.7840	.8036	.7983	.7872	1965	.7671	.7733	.7954	.8040	.7850
1935	.7532	.7570	.8036	.8018	.7789						
						1966	.7570	.7652	.8096	.8064	.7846
1936	.7627	.7712	.8010	.8018	.7842	1967	.7539	.7604	.8095	.8124	.7841
1937	.7570	.7813	.8018	.8112	.7878	1968	.7641	.7730	.8123	.8095	.7897
1938	.7711	.7599	.7877	.7894	.7770	1969	.7648	.7755	.8111	.8173	.7922
1939	.7722	.7805	.8036	.8027	.7898	1970	.7636	.7667	.8027	.8155	.7871
1940	.7693	.7731	.8138	.8173	.7934						
						1971	.7570	.7673	.8007	.7929	.7795
						1972	.7641	.7723	.8112	.8131	.7902

Table 3. Owikeno (Rivers Inlet) and Fraser sockeye. Data for Owikeno are base-10 logarithms of fork length in decimeters for each life-history type, males and females being given equal weight. Data for Fraser are 1/3 of the base-10 logarithm of weight in pounds, as given in Annual Reports of the International Pacific Salmon Fisheries Commission.

Year	Owikeno			Fraser	Year	Owikeno			Fraser
	1/3	1/4	Mean			1/3	1/4	Mean	
1911					1941	.7208	.7859	.7534	.2476
1912	.7512	.7921	.7716		1942	.7393	.7921	.7657	.2727
1913	.7502	.7984	.7717		1943	.7229	.7850	.7540	.2504
1914	.7493	.7984	.7739		1944	.7281	.7741	.7511	.2648
1915	.7483	.7983	.7733	.2572	1945	.7281	.7859	.7570	.2522
1916	.7483	.7957	.7720	.2560	1946	.7239	.7957	.7598	.2566
1917	.7393	.7832	.7608	.2460	1947	.7196	.7805	.7501	.2633
1918	.7393	.7833	.7613	.2664	1948	.7342	.7974	.7658	.2476
1919	.7383	.7814	.7599	.2491	1949	.7301	.7721	.7511	.2557
1920	-	.7974	-	.2599	1950	.7260	.7974	.7617	.2809
1921	.7463	.7831	.7647	.2567	1951	.7453	.8079	.7766	.2859
1922	.7403	.7777	.7590	.2606	1952	.7363	.8113	.7738	.2775
1923	.7383	.7767	.7575	.2645	1953	.7413	.8181	.7797	.2613
1924	.7373	.7814	.7594	.2494	1954	.7433	.8130	.7782	.2784
1925	.7352	.7913	.7633	.2535	1955	.7292	.8019	.7656	.2505
1926	.7483	.7859	.7671	.2667	1956	.7373	.7992	.7683	.2599
1927	.7363	.7777	.7570	.2613	1957	.7145	.7895	.7520	.2406
1928	.7423	.8001	.7712	.2683	1958	.7251	.7915	.7583	.2577
1929	.7393	.7931	.7662	.2574	1959	.7286	.7824	.7555	.2391
1930	.7443	.7992	.7718	.2725	1960	.7316	.7842	.7579	.2384
1931	.7302	.7886	.7594	.2590	1961	.7418	.7983	.7700	.2517
1932	.7393	.7868	.7631	.2699	1962	.7426	.7911	.7669	.2736
1933	.7322	.7904	.7613	.2449	1963	.7399	.8091	.7745	.2473
1934	.7373	.7940	.7657	.2639	1964	.7382	.7993	.7687	.2552
1935	.7393	.7966	.7680	.2543	1965	.7362	.7824	.7593	.2525
1936	.7091	.7702	.7397	.2703	1966	.7382	.8039	.7711	.2749
1937	.7302	.7750	.7526	.2347	1967	.7255	.7911	.7583	.2468
1938	.7502	.8070	.7786	.2751	1968	.7301	.7971	.7636	.2547
1939	.7302	.7868	.7585	.2525	1969	.7346	.7910	.7628	.2517
1940	.7363	.8087	.7725	.2676	1970	.7400	.7766	.7583	.2625
					1971	.7448	.7974	.7711	.2557
					1972	.7243	.7968	.7606	.2557
					1973				.2552
					1974				.2710

Table 4. Indices of size of British Columbia sockeye used for comparison with oceanographic conditions. N = Nass; S = Skeena; O = Owikeno; F = Fraser. The "actual" size index for N, S, and O is the base-10 logarithm of mean fork length in decimeters; for F it is one-third of the base-10 logarithm of mean weight in pounds. The "residual" indices are deviations from the line of linear regression of the actual size index on time (i.e. the observed size less the computed size), multiplied by 100. See the text for Fraser data to 1980.

Year	Actual				Residual			
	N	S	O	F	N	S	O	F
1944	.7972	.7700	.7511	.2648	-0.229	-1.008	-1.035	+0.28
1945	.7913	.7780	.7570	.2522	-0.778	-0.233	-0.461	-0.96
1946	.8016	.7832	.7598	.2560	+0.293	+0.263	-0.197	-0.49
1947	.7956	.7812	.7501	.2633	-0.266	+0.038	-1.184	-0.20
1948	.8038	.7805	.7658	.2476	+0.595	-0.056	+0.370	-1.35
1949	.7948	.7770	.7511	.2557	-0.264	-0.431	-1.116	-0.52
1950	.7977	.7852	.7617	.2809	+0.067	+0.365	-0.072	+2.02
1951	.8045	.7869	.7766	.2859	+0.788	+0.510	+1.402	+2.55
1952	.8057	.7869	.7738	.2775	+0.949	+0.486	+1.105	+1.73
1953	.8074	.7916	.7797	.2613	+1.160	+0.931	+1.679	+0.13
1954	.8076	.7897	.7782	.2844	+1.221	+0.717	+1.513	+1.86
1955	.7919	.7788	.7655	.2050	-0.308	-0.398	+0.227	-0.91
1956	.7935	.7902	.7683	.2599	-0.107	+0.718	0.490	+0.06
1957	.7891	.7814	.7520	.2406	-0.506	-0.187	-1.156	-1.85
1958	.7904	-	.7583	.2577	-0.335	-	-0.542	-0.12
1959	.7859	.7764	.7555	.2391	-0.744	-0.736	-0.838	-1.96
1960	.7791	.7768	.7579	.2384	-1.383	-0.721	-0.614	-2.00
1961	.7818	.7789	.7700	.2517	-1.072	-0.535	+0.579	-0.65
1962	.7901	.7855	.7669	.2736	-0.201	+0.100	+0.253	+1.56
1963	.7861	.7884	.7745	.2473	-0.560	+0.366	+0.997	-1.05
1964	.7893	.7799	.7687	.2552	-0.199	-0.509	+0.401	-0.24
1965	.7939	.7849	.7593	.2525	+0.303	-0.033	-0.556	-0.48
1966	.7867	.7845	.7711	.2749	-0.376	-0.098	+0.068	+1.78
1967	.7908	.7840	.7583	.2468	+0.075	-0.172	-0.688	-1.01
1968	.7942	.7897	.7636	.2547	+0.456	+0.373	-0.174	-0.20
1969	.7938	.7922	.7628	.2517	+0.457	+0.599	-0.270	-0.48
1970	.7882	.7871	.7583	.2625	-0.062	+0.064	-0.737	+0.63
1971	.7896	.7794	.7711	.2557	+0.119	-0.730	+0.527	+0.03
1972	.7973	.7902	.7606	.2557	+0.930	+0.325	-0.539	-0.00
1973				.2552				-0.00
1974				.2710				+1.56

Table 5 Round weight in hundredweight (100 lb or 45.35924 kg), of sockeye landed in British Columbia during 1951-75, by Areas and gears. GN = gillnets; S = seines; T = trolls.

Year	Area 1				Area 2E			
	GN	S	T	Total	GN	S	T	Total
1951	1	65	5	71				
1952	4	126	2	132				
1953	141	24	12	177		2		2
1954	3	2	1	6	1	2		3
1955			7	7		132		132
1956	88	66	4	158		1		1
1957	23		15	38				
1958	250	61	82	393			1	1
1959	55		44	99	23		5	28
1960	294	7	18	319				
1961	150	3	18	171				
1962	1060	18	13	1091	5	1		6
1963	320	9	16	345	8			8
1964	672	17	16	705	21	3		24
1965	1111	395	22	1528	39	1	1	41
1966	925	92	12	1029	7		6	13
1967	1826	108	58	1992	36		18	54
1968	3223	102	45	3370	1		4	5
1969	2488	205	56	2749	7		4	11
1970	3371	68	46	3485	10	1	26	37
1971	3117	428	72	3617	29		22	51
1972	3295	838	47	4180	2	6	36	44
1973	1050	910	35	1995	10	50	12	72
1974	750	310	635	1695	30	160	176	366
1975	1020	510	506	2036	20	50		70
Total	25,237	4,364	1,787	31,388	249	409	311	969
M tons	1,145	198	81	1,424	11	19	14	44

Table 5 (cont'd)

Year	Area 2W				Area 3			
	GN	S	T	Total	GN	S	T	Total
1951		263		263	14004	504	34	14542
1952		1		1	18939	600	2	19541
1953		76		76	11795	1566	2	13363
1954		2		2	6786	250		7036
1955		207		207	9171	149	1	9321
1956	13	17		30	14828	618	2	15448
1957	77	285		362	5364	3130	11	8505
1958	173			173	16873	8110	12	24995
1959	38	4		42	12775	716	19	13510
1960	93	23		116	6977	300	6	7283
1961	48			48	13473	3128	6	16607
1962	163	90		253	13558	348	13	13919
1963	183			183	1666	35	12	1713
1964	58			58	8135	2787	38	10960
1965	25			25	6801	853	9	7663
1966	113			113	8965	1842	6	10813
1967	24		1	25	13399	13074	14	26487
1968	26	48		74	13954	3699	40	17693
1969	96	1	1	98	9776	2288	34	12098
1970	14	2	7	23	6559	827	19	7405
1971	127	7	2	136	8235	3065	44	11344
1972	232	19	9	260	12165	2305	36	14506
1973	110			110	32860	2650	47	35557
1974	50	1620	294	1964	21700	12450	106	34256
1975	50	310		360	5360	2160		7520
Total	1,713	2,975	314	5,002	294,118	67,454	513	362,085
M tons	78	135	14	227	13,341	3,060	23	16,424

Table 5 (cont'd)

Year	Area 4				Area 5			
	GN	S	T	Total	GN	S	T	Total
1951	43433		5	43438	2586	1661	1	4248
1952	77507		4	77511	2502	1879	1	4382
1953	42471		2	42473	3551	1537	1	5089
1954	39781	33	2	39816	3841	1601		5442
1955	9481	2		9483	3347	797		4144
1956	8793	3		8796	3207	906		4113
1957	16128	124	1	16253	1149	362		1511
1958	38595		2	38597	3349	841	1	4191
1959	11997	2	7	12006	3377	1852	5	5234
1960	10191	17	2	10210	1980	696	1	2677
1961	52510	7	4	52521	3467	1854	1	5322
1962	30473	1	4	30478	6161	1008	8	7177
1963	7967	37	18	8022	4619	805	27	5451
1964	49419	45	27	49491	7232	2005	4	9241
1965	16256	2	6	16264	6899	730	5	7634
1966	37121		11	37132	5510	2533	15	8058
1967	62315	7	2	62324	2603	576	1	3180
1968	53930	63	19	54012	3629	722	11	4362
1969	32117	20	182	32319	2486	147	2	2635
1970	31151	16	584	31751	6750	905	20	7675
1971	49765	1329	47	51141	2798	675	4	3477
1972	42680	1693	20	44393	4039	691	9	4739
1973	76720	4460	94	81274	1330	500	24	1854
1974	74820	13810	71	88701	730	120	12	862
1975	24430	2680	35	27145	570	1060		1630
Total	940,051	24,351	1,149	965,551	87,712	26,463	153	114,328
M tons	42,640	1,105	52	43,797	3,979	1,200	7	5,186

Table 5 (cont'd)

Year	Area 6				Area 7			
	GN	S	T	Total	GN	S	T	Total
1951	1811	3073		4884	785	88	2	875
1952	1234	3450		4684	609	113	1	723
1953	2789	2980	2	5771	405	342	4	751
1954	3654	3391		7045	572	178		750
1955	1988	1250		3238	459	312	1	772
1956	1070	1383		2453	387	262	1	650
1957	989	633		1622	284	146	11	441
1958	2040	4328		6368	747	92	19	858
1959	1511	414		1925	172	127	4	303
1960	1802	1277		3079	279	118	5	402
1961	2409	1701	5	4115	480	193	8	681
1962	3122	2196	2	5320	1131	153	11	1295
1963	1782	1163	2	2947	1026	173	13	1212
1964	5749	3311	38	9098	1121	431	19	1571
1965	3006	1375	29	4410	912	519	6	1437
1966	2259	1864	11	4134	2282	517	11	2810
1967	1872	1404	5	3281	892	485	24	1401
1968	2157	2344	34	4535	1243	785	29	2057
1969	1235	750	1	1986	159	221	25	405
1970	2803	2379	49	5231	2817	403	58	3278
1971	910	891	2	1803	656	794	33	1483
1972	2032	3705	26	5763	2626	1049	15	3690
1973	1080	2650	24	3754	910	1280	165	2355
1974	1560	2290	24	3874	3270	1520	35	4825
1975	730	510	12	1252	740	960	12	1712
Total	51,594	50,712	266	102,572	24,964	11,261	512	36,737
M tons	2,340	2,300	12	4,653	1,132	511	23	1,666

Table 5 (cont'd)

Year	Area 8				Area 9			
	GN	S	T	Total	GN	S	T	Total
1951	5358	569	2	5929	69591	14		69605
1952	7768	597		8365	58728	1		58729
1953	5369	2876	2	8247	88284	13		88297
1954	5230	1587		6817	35640	1		35641
1955	2017	1362	1	3380	34075	5		34080
1956	4431	847	1	5279	77051	2		77053
1957	1752	636	7	2395	18859			18859
1958	6749	4788	19	11556	65335	9	13	65357
1959	2380	1055	5	3440	25165		1	25166
1960	2255	1207	4	3466	27443	10		27453
1961	3823	1901	6	5730	49263	5		49268
1962	3601	3828	6	7435	51187	56		51243
1963	2830	3066	2	5898	27510			27510
1964	4831	12603	20	17454	70796		1052	71848
1965	1490	1527	2	3019	30445		1	30446
1966	2299	1377	15	3691	32798			32798
1967	4013	5158	46	9217	48725	8	162	48895
1968	2989	8643	292	11915	142591	44380	3346	190317
1969	1572	440	8	2020	38102	555	340	38997
1970	2106	2170	100	4376	1050	21	11	1082
1971	5223	2566	53	7842	20839	520		21359
1972	1267	2477	20	3764	18277	451	4	18732
1973	2210	11550	118	13878	97730	24440	1459	123629
1974	2690	4310	329	7329	7600	480	35	8115
1975	7040	3610	12	10662	1930	200		2130
Total	91,293	80,741	1,070	173,104	1,139,014	71,171	6,424	1216,609
M tons	4,141	3,662	49	7,852	51,665	3,228	291	54,985

Table 5 (cont'd)

Year	Area 10				Area 11			
	GN	S	T	Total	GN	S	T	Total
1951	31637	13		31650	2479			2479
1952	24445	3		24448	615			615
1953	21555	1		21556	1744	1		1745
1954	12064			12064	1078			1078
1955	20173			20173	942			942
1956	31524			31524	392			392
1957	3686			3686	241		1	242
1958	14740		5	14745	934		35	969
1959	6954		4	6958	358		4	362
1960	13117		2	13119	1293		2	1295
1961	13157			13157	588			588
1962	13638	1	1	13640	569		1	570
1963	11324		1	11325	258		66	324
1964	15754			15754	1045		1	1046
1965	15668			15668	629			629
1966	11582		11	11593	434	2	5	441
1967	14500		524	15024	1913	3	41	1957
1968	30948		1149	32097	3952		61	4013
1969	10156	2	96	10254	1796	16	66	1878
1970	5168	2	12	5182	318	219	1354	1891
1971	8886		116	9002	285	75	67	427
1972	3209		6	3215	80		78	158
1973	20380		12	20392	50		576	626
1974	25040	90	106	25236	1320	70	1224	2614
1975	3270	20		3290	1100		35	1135
Total	382,575	132	2,045	384,752	24,413	386	3,617	28,416
M tons	17,353	6	93	17,452	1,107	18	164	1,289

Table 5 (cont'd)

Year	Area 12				Area 13			
	GN	S	T	Total	GN	S	T	Total
1951	7709	7689	75	15473	561	2523	1	3085
1952	5960	10347	16	16323	423	2015	4	2442
1953	7940	16681	60	24681	747	7906	2	8655
1954	3596	3085	31	6712	494	2612	9	3115
1955	2480	5606	99	8185	354	2008	2	2364
1956	3803	3553	27	7383	750	1323	6	2079
1957	5132	17516	289	22937	977	8172	5	9154
1958	35876	84630	4848	125354	3459	134724	367	138550
1959	3357	11511	1053	15921	503	4066	18	4587
1960	4779	6138	207	11124	693	1645	2	2340
1961	12113	16846	453	29412	1559	5046	40	6645
1962	4346	4960	205	9511	130	177	38	345
1963	2989	8468	152	11609	259	1297	7	1563
1964	5986	2932	116	9034	82	364	8	454
1965	3348	4521	41	7910	165	614	33	812
1966	15411	23244	644	39299	1726	6944	58	8728
1967	20793	39432	1554	61779	2886	13142	279	16307
1968	13782	9164	1173	24119	1136	1470	39	2645
1969	13533	10179	586	24298	780	3911	22	4713
1970	23595	29172	2781	55548	1993	8827	40	10860
1971	12088	16936	279	29303	989	6619	66	7674
1972	16311	11070	73	27454	1037	4108	18	5163
1973	7350	9680	341	17371	850	3690	12	4552
1974	17560	44730	1424	63714	1420	15420	35	16875
1975	3920	4470	82	8472	120	1220	24	1364
Total	253,757	402,560	16,609	672,926	24,093	239,843	1,135	265,071
M tons	11,510	18,260	753	30,523	1,093	10,879	51	12,023

Table 5 (cont'd)

Year	Area 14				Area 15			
	GN	S	T	Total	GN	S	T	Total
1951	1	1		2	2			2
1952	7			7	1		1	2
1953	3			3	1	1	1	3
1954	6	86		92	2			2
1955	3		1	4	1			1
1956	2		1	3	3			3
1957	26		1	27	4	1	1	6
1958	138	602	9	749	20	13		33
1959	12		7	19	1			1
1960	5	4	1	10				0
1961		9	5	14	1			1
1962	1		7	8	4		4	8
1963				0	2	2		4
1964				0			1	1
1965			8	8	2			2
1966			8	8	2			2
1967			15	15				0
1968			8	8			2	2
1969				0	2		4	6
1970	6		24	30	2		4	6
1971			18	18	13		15	28
1972			4	4	46	4	1	51
1973				0				0
1974			35	35	10			10
1975			12	12				0
Total	210	702	164	1,076	119	21	34	174
M tons	10	32	7	49	5	1	2	8

Table 5 (cont'd)

Year	Area 16				Area 17			
	GN	S	T	Total	GN	S	T	Total
1951	66	3	6	75	28	16	7	51
1952	136		1	137	42		6	48
1953	162	7	1	170	28	149	1	178
1954	193	24	1	218	472	10		482
1955	184	35	2	221	134		4	138
1956	183		1	184	24			24
1957	206	112	4	322	72	1		73
1958	2282	1396	24	3702	1655	3504	5	5164
1959	259	89	5	353	476	397	15	888
1960	109	1		110	42		11	53
1961	450	25	7	482	21	8	122	151
1962	327	254	7	588	17	14	16	47
1963	91	72	9	172	81	1	79	161
1964	37			37	4		1	5
1965	3		1	4	1			1
1966	248	3	12	263	30		12	42
1967	120	221	19	360	16	1	96	113
1968	322		18	340	5		2	7
1969	763	263	9	1035	49	41	138	228
1970	244	45	16	305	43	6	151	200
1971	656	1036	34	1726	569	3997	1427	5993
1972	1468	261	16	1745	231	82	261	574
1973	950	30		980	360	140	694	1194
1974	1240	2470	24	3734	1600	3180	3718	8498
1975	120	120		240	60		1212	1272
Total	10,819	6,467	217	17,503	6,060	11,547	7,978	25,585
M tons	491	293	10	794	275	524	362	1,161

Table 5 (cont'd)

Year	Area 18				Area 19			
	GN	S	T	Total	GN	S	T	Total
1951	122	32		154	6			6
1952	73	139		212				
1953	46	351		397	2	83		85
1954	1195	59337		60532	137	1906		
1955	17	20		37	20			20
1956	70			70	13	39		52
1957	6	4		10	29	722	1	752
1958	138	6274		6412	124	2721		2845
1959	113	1571		1684		1	1	2
1960	89	177		266	302			302
1961	17			17	21		1	22
1962	2			2		418	2	420
1963	105	775	51	931	7	189		196
1964	31			31		28		28
1965	165	26	1	192	19			19
1966	194			194	12		1	13
1967	209	328	18	555				
1968	140		1	141				
1969	277	1171	2	1450	197			197
1970	99		18	117	6			6
1971	451	2058	84	2593				
1972	85	92	34	211				
1973	240	170	47	457	30			30
1974	320	7280	576	4176				
1975	50	370	329	749				
Total	4,254	80,175	1,161	85,590	925	6,107	6	7,038
M tons	193	3,637	53	3,882	42	277		319

Table 5 (cont'd)

Year	Area 20				Area 21			
	GN	S	T	Total	GN	S	T	Total
1951	117	17707		17824	150	743	5	898
1952		12272		12272		294	2	296
1953	250	36797		37047	17	492	14	523
1954	5749	108798		114547	114	4957	21	5092
1955	5183	27002		32185	726	1350	6	2082
1956	3914	12103		16017	2018	1871	6	3895
1957	9376	24491	4	33871			7	7
1958	27145	146386	7	173538			21	21
1959	6519	25987	100	32606			34	34
1960	11462	19005	5	30472			1	1
1961	16491	20106	26	36623			12	12
1962	8536	10554	7	19097			20	20
1963	2669	5643	31	8343			32	32
1964	1552	405	4	1961			8	8
1965	5034	4293	9	9336			8	8
1966	19792	27998	4	47794			25	25
1967	15800	35479	229	51508			365	365
1968	2544	763		3307			31	31
1969	18061	18130	154	36345			334	334
1970	26246	27015	1138	54399	22		716	738
1971	28849	69418	288	98555		85	452	537
1972	15894	16534	91	32519			13	13
1973	18830	63710	118	82658			188	188
1974	21930	59460	259	81649			329	329
1975	2990	2130	12	5132			82	82
Total	274,933	792,186	2,846	1069,605	3,047	9,792	2,732	15,571
M tons	12,471	35,933	113	48,516	138	444	124	706

Table 5 (cont'd)

Year	Area 22				Area 23			
	GN	S	T	Total	GN	S	T	Total
1951	162	1	1	164	3954	24	9	3987
1952					2723	1	11	2735
1953	1355			1355	3832	49	109	3990
1954	576			576	1978	1	1048	3027
1955	18			18	1531	12	111	1654
1956	54			54	488		18	506
1957					568		75	643
1958					420		219	639
1959					341	1	905	1247
1960					413		121	534
1961					1079	8	308	1395
1962					726	42	262	1030
1963					396	124	171	691
1964					513	5	145	663
1965					848		362	1210
1966					1431	15	878	2324
1967					1171	363	4428	5962
1968					1367		1111	2478
1969					2611	81	1148	3840
1970					2251		4207	6458
1971					1171	367	5534	7072
1972					5139	4	422	5565
1973					9350	1620	1965	12935
1974					7530	3970	11141	22641
1975					6370	4200	1035	11605
Total	2,165	1	1	2,167	58,201	10,887	35,743	104,831
M tons	98			98	2,640	494	1,621	4,755

Table 5 (cont'd)

Year	Area 24				Area 25			
	GN	S	T	Total	GN	S	T	Total
1951	3	2685	81	2769	2		76	78
1952		6718	16	6734			8	8
1953	61	5040	40	5141			29	29
1954		943	187	1130		1	302	303
1955	26	1854	75	1955		1	56	57
1956	4	1498	13	1515			21	21
1957	21	1243	99	1363			140	140
1958	138	56	132	326			385	385
1959	85	4885	255	5195			116	116
1960	26	2162	116	2304			52	52
1961	72	825	206	1103		1	62	63
1962	123	1785	214	2122	4		411	415
1963	38	1077	101	1216	15		42	57
1964	152	1553	116	1821			33	33
1965	145	1777	428	2350			33	33
1966	65	2157	1033	3255			293	293
1967	21	1313	6136	7470			388	388
1968	72	2522	1862	4456	1	15	940	956
1969		1193	2312	3505		3	2214	2217
1970	98	253	6013	6364	1	1	2519	2521
1971	46	719	11187	11952			9211	9211
1972	4	7	589	600	9		324	333
1973			2600	2600	20		282	302
1974			12012	12012		10	11082	11092
1975			1553	1553	20		200	220
Total	1,200	42,265	47,346	90,811	72	32	29,219	29,323
M tons	54	1,917	2,148	4,119	3	1	1,325	1,330

Table 5 (cont'd)

Year	Area 26				Area 27			
	GN	S	T	Total	GN	S	T	Total
1951		5	84	89		2	138	140
1952			9	9		1	20	21
1953			24	24		246	18	264
1954			67	67	5	569	19	593
1955			35	35	1	4	53	58
1956			19	19		1	6	7
1957			60	60			49	49
1958			311	311		17	402	419
1959			146	146	91		121	212
1960			47	47	77		44	121
1961	1		99	100			251	251
1962			267	267	51		286	337
1963			26	26	16		153	169
1964			149	149	622		92	714
1965			89	89	574		87	661
1966	13	3	246	262	982		74	1056
1967			362	362	933		1260	2193
1968	10		489	499	1103		1479	2582
1969	1		828	829	308	20	1888	2216
1970			3229	3229	443	3	2291	2737
1971			6064	6064	1612	3	6929	8544
1972			86	86	425		176	601
1973			200	200	1890		718	2608
1974	20		5953	5973	5840	10	10129	15979
1975	20	130	82	232	8890	690	435	10015
Total	65	138	18,971	19,174	23,863	1,566	27,118	52,547
M tons	3	6	861	870	1,082	71	1,230	2,383

Table 5 (cont'd)

Year	Area 28				Area 29AB			
	GN	S	T	Total	GN	S	T	Total
1951	172	2		174	56345			56345
1952	7			7	47774			47774
1953	32			32	63307			63307
1954	147			147	129908	1063		130971
1955	71			71	22979			22979
1956	10			10	26021			26021
1957	7			7	24389			24389
1958	2514			2514	84994			84994
1959	4			4	36597			36597
1960	3			3	25813			25813
1961	16			16	25199		121	25320
1962	25			25	24940		31	24971
1963	86		12	98	20994		348	21342
1964	70			70	17360			17360
1965	96			96	33240		12	33252
1966	9			9	27522		62	27584
1967					34057		1008	35065
1968					32735		14	32749
1969					36870		247	37117
1970					26104		269	26373
1971					55847	6523	388	62758
1972					20139		48	20187
1973					40570		282	40852
1974					36470		1141	37611
1975					18290		965	19255
Total	3,269	2	12	3,283	968,464	7,586	4,936	980,986
M tons	148		1	149	43,929	344	224	44,497

Table 5 (cont'd)

Year	Area 29C			Area 29D
	GN	T	Total	GN
1951	5849		5849	13086
1952	3761		3761	15971
1953	4644		4644	15343
1954	14650		14650	10261
1955	2253		2253	6301
1956	1040		1040	10193
1957	1351		1351	8237
1958	18476	1	18477	8511
1959	3370		3370	8544
1960	1294		1294	10532
1961	2573		2573	13813
1962	1552	14	1566	7844
1963	2159	1	2160	5021
1964	1301		1301	8587
1965	1778	1	1779	15635
1966	1099		1099	12167
1967	2277	89	2366	11983
1968	1685	4	1689	13415
1969	2117		2117	15408
1970	1824		1824	7932
1971	3295	53	3348	14825
1972	993		993	10177
1973	3050	71	3121	18820
1974	2890	153	3043	6680
1975	880	12	892	5120
Total	86,161	399	86,560	274,406
M tons	3,908	18	3,926	12,447

Table 6. Mean weight in pounds of sockeye taken by three gears in most of the British Columbia Statistical Areas. GN = gillnet; S = seine; T = troll; but in this and later tables the Area 20 seine catch includes a rather small proportion of fish caught in the Sooke traps, through 1958. Mean values do not include data after 1975. When less than a complete 1951-1975 series is available, the "mean" is the 1963 value computed from the linear regression of weight on time.

	Area 1			Area 3			Area 4	
	GN	S	T	GN	S	T	GN	S
1951	-	5.09	-	6.44	6.36	-	6.28	-
1952	-	4.75	-	6.43	6.00	-	5.99	-
1953	6.54	4.88	6.88	6.75	6.62	-	6.44	-
1954	-	-	-	6.91	7.36	-	6.96	7.53
1955	-	-	-	5.92	5.69	-	6.02	-
1956	5.29	5.09	-	6.07	5.94	-	5.90	-
1957	5.46	-	6.07	6.21	5.52	-	5.76	5.52
1958	5.99	4.44	-	6.21	6.39	-	6.41	-
1959	5.39	-	5.72	5.96	5.77	-	6.13	-
1960	5.71	-	5.98	5.49	5.08	-	5.49	-
1961	5.81	-	6.89	5.92	5.85	-	5.87	-
1962	5.68	-	7.11	6.39	5.91	-	6.29	-
1963	5.99	-	6.21	5.85	4.89	-	5.63	5.71
1964	6.32	-	6.28	6.45	6.37	7.53	6.46	6.27
1965	5.85	5.54	6.52	5.69	5.14	-	5.53	-
1966	6.48	5.29	7.85	6.40	5.38	-	6.26	-
1967	6.03	6.00	6.39	6.16	5.89	-	5.97	-
1968	6.67	5.24	7.32	6.84	6.73	6.71	6.92	6.95
1969	6.12	5.42	5.81	6.23	5.31	-	5.99	-
1970	5.97	5.28	6.31	6.03	5.35	-	5.82	-
1971	6.43	5.86	6.32	5.95	5.54	5.98	5.97	5.72
1972	6.34	5.97	6.71	6.38	5.91	5.96	6.60	6.10
1973	6.45	6.16	7.62	6.40	5.88	-	6.23	5.88
1974	6.58	6.18	6.75	6.85	6.14	6.51	6.47	6.14
1975	6.06	5.23	6.25	5.99	5.35	-	5.64	4.91
Mean (1963)	5.99	5.37	6.53	6.24	5.85	-	6.12	-
1976	6.47	5.54	-	6.16	5.84	-	5.35	5.77
1977	6.33	7.22	6.14	6.67	6.23	-	6.36	6.30
1978	-	6.43	-	6.95	6.09	-	7.00	6.58
1979	5.59	6.00	6.04	5.82	5.30	-	5.44	5.81
1980	5.80	5.79	6.28	6.43	5.55	-	6.21	6.16

Table 6 (cont'd)

	Area 5		Area 6		Area 7		Area 8	
	GN	S	GN	S	GN	S	GN	S
1951	6.40	5.74	6.78	5.97	5.52	4.92	5.30	4.71
1952	6.08	5.61	7.25	5.87	5.02	4.29	5.18	4.44
1953	6.29	5.60	7.36	6.44	5.21	4.35	4.80	4.66
1954	6.68	6.01	8.18	7.89	5.21	4.55	5.38	4.78
1955	6.09	4.82	6.68	4.88	5.08	3.77	4.57	3.71
1956	6.06	5.15	6.47	5.12	4.92	4.07	4.96	4.39
1957	6.03	4.81	6.38	4.68	5.21	4.20	4.96	4.23
1958	5.66	5.39	5.98	4.78	4.92	4.34	5.32	4.75
1959	6.09	6.17	6.47	4.89	5.07	4.10	4.33	3.82
1960	5.69	4.58	6.12	4.76	4.79	3.81	4.10	3.78
1961	5.83	5.57	6.03	5.29	5.29	4.09	4.63	4.32
1962	6.16	5.53	6.60	5.65	5.01	3.99	4.86	4.26
1963	5.57	4.67	5.38	4.35	4.47	3.66	4.16	3.66
1964	6.26	6.33	6.90	6.45	5.46	4.68	5.68	5.70
1965	5.78	5.02	5.90	4.94	4.92	3.61	4.51	3.41
1966	6.44	6.73	6.22	5.28	5.77	4.01	5.02	3.71
1967	5.55	4.93	5.77	4.76	4.86	3.73	4.14	3.76
1968	6.12	5.28	6.30	5.92	6.41	5.48	5.84	5.99
1969	5.76	4.56	6.36	5.13	5.16	3.98	4.78	4.09
1970	6.03	5.12	6.25	5.06	5.93	3.70	5.17	3.67
1971	5.96	5.37	6.20	5.02	5.43	5.00	4.69	4.60
1972	6.38	5.49	6.36	5.32	6.00	4.20	5.40	3.99
1973	6.35	5.28	6.48	5.29	6.07	5.12	5.83	6.29
1974	6.30	5.66	7.29	6.44	7.14	5.84	5.98	5.38
1975	5.87	5.46	6.34	5.41	5.81	4.47	4.87	4.43
Mean (1963)	6.06	5.40	6.48	5.42	5.39	4.32	4.98	4.42
1976	5.97	-	6.48	4.85	6.08	5.25	5.51	5.02
1977	6.58	5.87	6.67	5.94	6.82	6.05	4.57	4.89
1978	6.17	5.70	6.94	5.80	7.13	5.13	5.50	5.44
1979	5.71	5.05	6.12	5.07	6.01	5.09	5.18	4.56
1980	5.94	5.76	6.32	5.32	6.24	5.25	5.40	4.94

Table 6 (cont'd)

	Area 9		Area 10	Area 11	Area 12		
	GN	S	GN	GN	GN	S	T
1951	6.85	-	7.21	7.96	6.03	6.52	7.80
1952	6.26	-	7.14	6.94	5.92	5.93	-
1953	5.80	-	5.87	5.66	5.84	5.53	6.89
1954	6.19	-	6.32	6.16	6.49	6.35	-
1955	5.83	-	6.20	6.44	5.85	5.52	6.18
1956	7.19	-	7.13	6.81	6.31	5.64	7.54
1957	5.04	-	5.79	5.80	5.60	4.84	5.61
1958	6.42	-	6.59	6.61	6.21	6.13	6.31
1959	5.73	-	6.14	6.14	5.55	5.29	5.67
1960	5.32	-	5.98	5.92	5.56	5.23	6.13
1961	5.84	-	6.17	6.03	5.90	5.88	6.82
1962	4.95	6.18	5.41	5.43	6.08	5.99	6.73
1963	6.29	-	6.47	6.40	5.56	5.48	6.42
1964	6.72	-	6.66	6.65	5.75	5.44	6.68
1965	4.72	-	5.40	5.44	5.43	4.99	5.65
1966	6.21	-	6.73	6.64	6.55	6.34	7.41
1967	4.42	-	5.07	5.20	5.73	5.70	6.01
1968	7.07	6.85	6.82	6.74	5.99	5.61	6.36
1969	5.33	4.39	6.08	6.06	5.66	5.20	6.14
1970	5.67	-	6.25	6.06	6.34	6.21	6.86
1971	5.33	4.49	6.22	5.67	5.73	5.70	6.65
1972	4.97	4.07	5.40	6.36	6.01	5.63	5.55
1973	7.18	6.12	6.92	6.28	6.19	5.60	6.85
1974	6.91	5.50	7.23	6.93	6.69	6.80	6.89
1975	5.30	4.76	6.24	5.58	5.53	5.14	-
Mean (1963)	5.90	-	6.30	6.24	5.94	5.71	6.55
1976	5.97	4.84	6.37	5.97	6.13	5.80	6.07
1977	6.38	5.13	5.98	6.38	6.29	6.31	6.77
1978	7.67	6.39	7.47	6.90	6.66	6.80	7.04
1979	4.95	-	6.26	6.25	6.08	5.91	6.12
1980	-	-	5.90	6.18	5.74	5.50	5.77

Table 6 (cont'd)

	Area 13			Area 17			Area 18	
	GN	S	T	GN	S	T	GN	S
1951	5.62	7.08	-	-	-	-	7.31	6.69
1952	6.24	6.82	-	7.25	-	-	7.07	6.89
1953	6.10	5.94	-	-	6.17	-	6.10	6.24
1954	6.94	6.70	-	7.31	-	-	7.05	7.34
1955	5.93	5.79	-	6.10	-	-	-	-
1956	6.56	6.17	-	-	-	-	6.42	-
1957	5.70	4.86	-	5.59	-	-	-	-
1958	6.23	6.02	6.14	6.43	6.19	-	6.37	6.39
1959	5.74	5.24	-	5.81	5.37	-	5.93	5.55
1960	5.59	5.18	-	5.43	-	-	5.84	5.36
1961	6.00	5.74	6.36	-	-	5.36	-	-
1962	6.79	6.29	6.87	-	-	-	-	-
1963	5.99	5.66	-	5.86	-	6.28	5.64	5.85
1964	6.03	5.68	-	-	-	-	5.70	-
1965	5.83	4.68	-	-	-	-	5.83	-
1966	6.78	6.56	7.42	6.79	-	-	6.44	-
1967	6.16	6.05	5.99	-	-	6.27	5.79	6.01
1968	5.97	5.44	5.84	-	-	-	5.96	-
1969	5.75	5.51	-	6.03	5.20	5.26	5.91	5.58
1970	6.40	6.30	6.36	6.40	-	6.56	6.24	-
1971	5.92	6.01	6.05	6.28	6.67	6.51	6.12	6.36
1972	5.94	5.80	-	6.14	6.31	6.13	5.97	5.86
1973	6.25	5.74	-	6.06	5.60	6.58	5.96	5.87
1974	6.76	6.79	-	6.83	6.99	6.84	6.69	6.89
1975	5.52	5.39	-	-	-	6.61	-	6.23
Mean (1963)	6.11	5.90	6.43	6.29	6.01	-	6.23	6.22
1976	6.19	5.98	-	6.20	6.14	6.58	6.28	6.34
1977	6.44	6.38	-	5.92	-	6.13	6.19	6.38
1978	6.78	6.76	6.92	6.97	6.41	7.02	-	6.82
1979	6.15	6.21	6.43	5.63	-	6.76	5.70	5.85
1980	5.70	5.50	5.65	-	-	-	-	-

Table 6 (cont'd)

	Area 20			Area 21			Area 23		
	GN	S	T	GN	S	T	GN	S	T
1951	7.47	7.32	-	-	7.62	-	5.23	-	-
1952	-	7.02	-	-	7.16	-	5.44	-	-
1953	6.30	6.33	-	-	5.65	-	5.08	5.67	6.44
1954	7.21	7.40	-	-	7.39	-	5.15	-	7.72
1955	6.35	6.14	-	6.20	5.99	-	5.37	-	6.64
1956	6.24	6.45	-	6.69	6.57	-	5.46	-	-
1957	5.66	4.83	-	-	-	-	4.83	-	5.59
1958	6.37	6.18	-	-	-	-	5.06	-	6.67
1959	5.65	5.31	5.41	-	-	-	4.91	-	5.61
1960	5.72	5.43	-	-	-	-	4.52	-	5.98
1961	6.00	5.86	-	-	-	-	4.97	-	6.00
1962	6.64	6.64	-	-	-	-	4.67	5.49	6.98
1963	5.98	5.74	-	-	-	-	4.60	5.07	6.31
1964	5.81	5.52	-	-	-	-	4.62	-	5.89
1965	5.85	5.12	-	-	-	-	4.80	-	6.24
1966	6.84	6.87	-	-	-	-	4.96	-	7.35
1967	6.05	5.99	6.22	-	-	6.24	4.91	5.05	5.92
1968	5.91	5.59	-	-	-	-	4.74	-	6.11
1969	5.87	5.56	5.98	-	-	5.68	4.74	4.78	5.92
1970	6.46	6.40	6.73	6.63	-	6.73	4.95	-	6.89
1971	6.27	6.26	6.71	-	6.03	6.52	5.23	5.91	6.68
1972	6.05	5.87	6.04	-	-	-	4.59	-	6.23
1973	6.05	5.83	5.99	-	-	6.80	4.82	4.71	5.94
1974	6.50	6.75	7.32	-	-	6.53	5.31	4.88	6.98
1975	5.75	5.58	-	-	-	-	4.82	4.51	6.12
Mean (1963)	6.22	6.10	-	-	-	-	4.95	-	6.38
1976	6.14	5.99	5.25	-	-	-	5.00	4.68	5.71
1977	6.30	6.13	6.36	-	-	6.03	4.98	4.84	6.12
1978	6.60	6.75	6.76	-	-	6.75	5.70	5.45	7.05
1979	5.99	6.09	6.75	-	-	6.08	4.68	4.20	6.30
1980	5.73	5.48	-	-	-	5.97	4.84	4.42	5.56

Table 6 (cont'd)

	Area 24			Area 25	Area 27		Area 29AB	
	GN	S	T	T	GN	T	GN	T
1951	-	5.88	7.09	8.16	-	7.55	7.29	-
1952	-	5.80	-	-	-	-	7.10	-
1953	5.65	6.00	5.95	-	-	-	6.27	-
1954	-	5.78	7.59	-	-	-	7.26	-
1955	-	5.89	6.88	6.49	-	6.91	5.99	-
1956	-	5.47	-	-	-	-	6.42	-
1957	-	4.99	5.91	4.85	-	5.36	5.25	-
1958	5.32	5.22	6.54	6.89	-	7.01	6.21	-
1959	5.61	5.52	5.62	5.29	-	5.19	5.45	-
1960	-	5.29	5.89	6.06	-	5.75	5.42	-
1961	5.58	5.48	6.28	6.16	-	6.48	5.85	-
1962	5.24	5.10	7.32	6.64	6.57	6.94	6.47	-
1963	5.32	4.89	6.22	6.36	-	5.98	5.76	6.76
1964	5.42	5.40	6.41	-	6.26	6.65	5.90	-
1965	5.44	5.37	6.35	-	5.17	5.99	5.90	-
1966	5.66	5.42	7.47	7.72	6.35	6.65	6.52	8.17
1967	-	5.06	6.01	6.22	5.24	6.27	5.65	6.15
1968	5.15	5.57	6.00	6.21	6.71	6.59	5.77	-
1969	-	5.54	6.92	5.88	5.75	5.42	5.73	5.48
1970	5.77	5.89	6.74	6.94	5.95	6.88	6.32	6.61
1971	6.24	5.78	6.73	6.69	6.16	6.64	6.19	6.78
1972	-	-	6.15	6.25	5.99	5.85	6.00	7.60
1973	-	-	6.08	5.95	6.75	6.26	5.92	6.26
1974	-	-	6.80	6.92	6.64	6.66	6.67	7.19
1975	-	-	6.31	7.14	5.88	5.84	5.96	6.39
Mean (1963)	5.53	5.47	6.46	6.46	-	6.36	6.13	-
1976	-	4.07	5.99	5.58	6.15	5.77	6.18	5.84
1977	-	-	5.97	6.44	6.17	6.17	6.33	6.29
1978	-	6.75	6.75	6.88	-	6.97	6.49	7.06
1979	-	-	6.44	6.42	6.43	6.26	5.97	6.77
1980	-	-	5.61	5.35	-	5.66	5.61	-

Table 7. Mean round weight in pounds of sockeye caught by different gears, 1951-75, and the number of years of observations (N) on which each is based (from Table 6). When less than 25 years' observations are available, the figure shown is the size computed for 1963 from the linear regression of weight on time. Troll-caught fish have been converted to round weight by dividing by 0.85. Means are weighted by the catch taken by all methods in each Area (from Table 5). "Six-Area" means are for the Areas in which both gillnet and seine weights are available.

Region	Area	Catch	Gillnet		Seine		Troll	
			Wt.	N	Wt.	N	Wt.	N
Northern	1	3	5.99	21	5.37	18	6.53	19
	3	36	6.24	25	5.85	25		
	4	97	6.12	25				
Hecate Strait	5	11	6.06	25	5.40	25		
	6	10	6.48	25	5.42	25		
Central Coast	7	4	5.39	25	4.32	25		
	8	17	4.98	25	4.42	25		
	9	122	5.90	25				
	10	38	6.30	25				
	11	3	6.24	25				
N.-C. means			6.02		5.34		6.53	
Means (6 Areas)			5.93		5.34			
Johnstone Strait	12	67	5.94	25	5.71	25	6.55	25
	13	27	6.11	25	5.90	25	6.43	8
Georgia Strait	17	3	6.29	15	6.01	8		
	18	9	6.23	20	6.22	15		
Fraser	29AB	134	6.13	25				
Juan de Fuca	20	107	6.22	24	6.08	25		
West coast of Vancouver I.	23	10	4.95	25	-	-	6.38	22
	24	9	5.53	12	5.47	21	6.46	23
	25	3	-	-	-	-	6.46	19
	27	5	-	-	-	-	6.36	21
Southern means			6.08		5.93		6.49	
Means (6 Areas)			6.10		5.93		-	
Overall means			6.05		5.77		6.49	

Table 8. Comparison of percentage representation, in catch and escapement, of the 4 commoner life-history types of sockeye of the Skeena run. C: catch; E: escapement; D: difference (escapement minus catch).

Year	Life-history type			
	1/3	1/4	2/3	2/4
1964				
C	22.5	70.6	5.4	1.1
E	29.4	65.5	4.1	0.8
D	+6.9	-5.1	-1.3	-0.3
1965				
C	43.2	48.7	4.7	3.2
E	59.3	31.2	4.9	4.6
D	+16.1	-17.5	+0.2	+1.4
1966				
C	44.9	45.6	6.2	2.4
E	46.9	40.6	7.4	5.0
D	-2.0	-5.0	+1.2	+2.6
1967				
C	44.2	51.0	1.9	2.8
E	63.9	31.3	2.5	2.2
D	+19.7	-19.7	+0.6	-0.6
1968				
C	11.1	82.9	3.4	2.5
E	14.2	80.8	2.3	2.7
D	+3.1	-2.1	-1.1	+0.02
1969				
C	48.4	42.4	6.4	2.5
E	59.5	33.8	2.0	1.0
D	+11.1	-8.6	-4.4	-1.5
Means				
C	35.72	56.87	4.67	2.42
E	45.53	47.20	3.87	2.72
D	+9.81	-9.67	-0.80	+0.30

Table 9. Trends in mean weight in pounds of sockeye caught by gillnet. N = number of years' data used; r = linear correlation coefficient; b = regression coefficient (lb/yr); 1951 and 1975 = computed sizes (lb) in the years indicated; change = computed change in size between 1951 and 1975 (lb). Means are weighted by the total catch by all gears in each Area (Table 5), rounded to the nearest million pounds.

Region	Area	Catch	N	r	b	1951	1975	Change
Northern	1	3	21	+0.546*	+0.0347	5.57	6.41	+0.84
	3	36	25	-0.042	-0.0021	6.26	6.21	-0.05
	4	97	25	-0.052	-0.0028	6.16	6.09	-0.07
Hecate Strait	5	11	25	-0.126	-0.0050	6.12	6.00	-0.12
	6	10	25	-0.353	-0.0280	6.82	6.15	-0.67
Central	7	4	25	+0.588**	+0.0472	4.82	5.95	+1.13
	8	17	25	+0.219	+0.0190	4.79	5.24	+0.45
	9	122	25	-0.150	-0.0164	6.09	5.70	-0.39
	10	38	25	-0.130	-0.0107	6.43	6.17	-0.26
	11	3	25	-0.292	-0.0242	6.53	5.95	-0.58
N.-C. means					-0.0075	6.11	5.93	-0.18
Johnstone Strait	12	67	25	+0.042	+0.0020	5.91	5.96	+0.05
	13	27	25	-0.014	-0.0008	6.12	6.10	-0.02
Georgia Strait	17	3	15	-0.123	-0.0090	6.40	6.18	-0.22
	18	9	20	-0.505*	-0.0328	6.62	5.83	-0.79
Fraser	29AB	134	25	-0.319	-0.0233	6.41	5.85	-0.56
Juan de Fuca	20	107	24	-0.344	-0.0227	6.49	5.94	-0.55
West coast Vancouver I.	23	10	25	-0.409	-0.0153	5.13	4.77	-0.36
	24	9	12	+0.316	+0.0178	5.32	5.74	+0.42
Southern means					-0.0157	6.26	5.88	-0.38
Overall means					-0.0117	6.19	5.91	-0.28
Percent change								-4.5%

Table 10. Trends in mean weight in pounds of sockeye caught by seine, and weighted means. Symbols as in Table 9.

Region	Area	Catch	N	r	b	1951	1975	Change
Northern	1	3	18	+0.680**	+0.0438	4.84	5.90	+1.06
	3	36	25	-0.351	-0.0273	6.18	5.53	-0.65
Hecate Strait	5	11	25	-0.077	-0.0057	5.46	5.33	-0.13
	6	10	25	-0.182	-0.0191	5.65	5.19	-0.46
Central	7	4	25	+0.260	+0.0205	4.07	4.56	+0.49
	8	17	25	+0.171	+0.0175	4.21	4.63	+0.42
N.-C. means					-0.0090	5.45	5.24	-0.21
Johnstone Strait	12	67	25	-0.060	-0.0040	5.76	5.66	-0.10
	13	27	25	-0.209	-0.0172	6.10	5.69	-0.41
Georgia Strait	17	3	8	+0.239	+0.0184	5.79	6.23	+0.44
	18	9	15	-0.315	-0.0205	6.46	5.97	-0.49
Juan de Fuca	20	107	25	-0.308	-0.0278	6.41	5.75	-0.66
West Coast Vancouver I.	24	9	21	-0.248	-0.0129	5.62	5.31	-0.31
Southern means					-0.0181	6.14	5.71	-0.43
Overall means					-0.0156	5.96	5.58	-0.38
Percent change								-6.4%

Table 11. Trends in mean weight in pounds of sockeye caught by trolling.
Symbols as in Table 9.

Region	Area	Catch	N	r	b	1951	1975	Change
Northern	1	3	19	+0.176	+0.0169	6.33	6.74	+0.41
Johnstone	12	67	22	-0.238	-0.0220	6.82	6.29	-0.53
Strait	13	27	8	-0.188	-0.0215	6.69	6.17	-0.52
West coast	23	10	22	-0.085	-0.0071	6.46	6.29	-0.17
Vancouver I.	24	9	23	-0.158	-0.0121	6.60	6.31	-0.29
	25	3	19	+0.025	+0.0028	6.45	6.52	+0.07
	27	5	21	-0.199	-0.0184	6.58	6.14	-0.44
Southern means					-0.0192	6.73	6.26	-0.47
Overall means					-0.0183	6.72	6.28	-0.44
Percent change								-6.5%

Table 12. Linear correlations (r) between sockeye size indices of different Areas, and number of pairs of observations (N). The 95% confidence level is about 0.26 for the whole series, and 0.36 for 1944-72.

	Skeena (4)		Owikenno (9)		Fraser (29 etc.)	
	r	N	r	N	r	N
<u>Whole series</u>						
Nass (3)	+0.136	55	+0.003	59	+0.345**	57
Skeena (4)			+0.044	55	+0.0004	56
Owikenno (9)					+0.402**	57
<u>1944-72</u>						
Nass (3)	+0.306	28	+0.272	29	+0.562**	29
Skeena (4)			+0.482**	28	+0.337	28
Owikenno (9)					+0.437*	29
<u>1944-72 (residuals)</u>						
Nass (3)	+0.699**	28	+0.476**	29	+0.441*	29
Skeena (4)			+0.531**	28	+0.476**	28
Owikenno (9)					+0.466**	29

Table 13. Correlation between total landings (all gears) and mean weight of sockeye taken by gillnets and by seines in five Areas.

Area	Gillnets		Seines	
	N	r	N	r
3	25	+0.409*	25	+0.340
4	25	+0.462*	10	+0.266
9	25	+0.551**	8	+0.785*
10	25	+0.604**	-	-
29A+B	25	+0.547**	-	-

Table 14. Time relations among the principal life-history types of successive year-classes of British Columbia sockeye in successive years. The symbol "F" indicates a year of freshwater growth, while "S" indicates a year of ocean growth (not a full year, in the first and last seasons). The complete range of maturing types is shown for the year 1906, these being marked by asterisks.

Life history type	Calendar year									
	1901	1902	1903	1904	1905	1906	1907	1908	1909	
<u>1900 year-class</u>										
1/2	F	S	S							
1/3	F	S	S	S						
1/4	F	S	S	S	S					
2/3	F	F	S	S	S					
2/4	F	F	S	S	S	S*				
<u>1901 year-class</u>										
1/2		F	S	S						
1/3		F	S	S	S					
1/4		F	S	S	S	S*				
2/3		F	F	S	S	S*				
2/4		F	F	S	S	S	S			
<u>1902 year-class</u>										
1/2			F	S	S					
1/3			F	S	S	S*				
1/4			F	S	S	S	S			
2/3			F	F	S	S	S			
2/4			F	F	S	S	S	S		
<u>1903 year-class</u>										
1/2				F	S	S*				
1/3				F	S	S	S			
1/4				F	S	S	S	S		
2/3				F	F	S	S	S		
2/4				F	F	S	S	S	S	

Table 15. Correlations between adult sizes of life-history types of the Nass run, and characteristics of each comparison.

a = same duration of ocean life
b = same duration of freshwater life
c = migrate to sea in the same calendar year
d = return from the sea in the same calendar year
e = return from the sea in adjacent years
2,3,4 = number of common calendar years in the ocean

Life-history types in	Statistic	Life-history types in calendar year n			
		1/3	2/3	1/4	2/4
<u>Year n</u>					
2/3	r	+0.682			
	z	+0.833 a,c,d,3			
1/4	r	+0.292	+0.110		
	z	+0.301 b,d,3	+0.110 d,3		
2/4	r	+0.576	+0.557	+0.633	
	z	+0.656 d,3	+0.628 b,d,3	+0.746 a,c,d,4	
<u>Year n + 1</u>					
1/3	r	+0.413	+0.460	+0.110	+0.390
	z	+0.439 a,b,e,2	+0.497 a,e,2	+0.110 b,e,2	+0.412 e,2
2/3	r	+0.451	+0.682	-0.178	+0.376
	z	+0.486 a,e,2	+0.833 a,b,e,2	-0.180 e,2	+0.395 b,e,2
1/4	r	+0.218	-0.050	+0.513	+0.343
	z	+0.222 b,c,e,3	-0.050 c,e,3	+0.567 a,b,e,3	+0.357 a,e,3
2/4	r	+0.488	+0.373	+0.373	+0.586
	z	+0.533 c,e,3	+0.392 b,c,e,3	+0.392 a,e,3	+0.672 a,b,e,3

Table 16. Correlations between adult sizes of life-history types of the Skeena run. See Table 15 and the text for explanation of the symbols.

Life-history types in	Statistic	Life history types in calendar year n			
		1/3	2/3	1/4	2/4
<u>Year n</u>					
2/3	r	+0.355			
	z	+0.371			
		a,c,d,3			
1/4	r	+0.195	+0.400		
	z	+0.198	+0.424		
		b,d,3	d,3		
2/4	r	+0.013	+0.353	+0.719	
	z	+0.013	+0.369	+0.906	
		d,3	b,d,3	a,c,d,4	
<u>Year n + 1</u>					
1/3	r	+0.182	-0.049	-0.146	-0.204
	z	+0.185	-0.049	-0.147	-0.207
		a,b,e,2	a,e,2	b,e,2	e,2
2/3	r	+0.159	-0.115	+0.112	-0.103
	z	+0.160	-0.116	+0.112	-0.103
		a,e,2	a,b,e,2	e,2	b,e,2
1/4	r	+0.171	+0.094	+0.423	+0.341
	z	+0.173	+0.094	+0.451	+0.355
		b,c,e,3	c,e,3	a,b,e,3	a,e,3
2/4	r	+0.089	+0.244	+0.371	+0.356
	z	+0.089	+0.249	+0.390	+0.372
		c,e,3	b,c,e,3	a,e,3	a,b,e,3

Table 17. Correlations between adult sizes of life-history types of the Owikeno run. See Table 15 and the text for explanation of the symbols a-e.

Life-history types in	Statistic	Life-history types in calendar year n	
		1/3	1/4
<u>Year n</u>			
1/4	r	+0.372	
	z	+0.391	
		b,d,3	
<u>Year n + 1</u>			
1/3	r	+0.299	-0.061
	z	+0.308	-0.061
		a,b,e,2	b,e,2
1/4	r	+0.110	+0.274
	z	+0.110	+0.281
		b,c,e,3	a,b,e,3

Table 18. Summary of correlations between life-history types within river systems. "Mean" columns give the arithmetic mean of the z-statistics and corresponding r values. N is the number of comparisons averaged. The types of comparisons are described in the text and summarized in Table 15.

Type of comparison	Statistic	Nass		Skeena		Owikeno	
		Mean	N	Mean	N	Mean	N
A. <u>Same-year comparisons</u>							
acd4	r	+0.633	1	+0.719	1		
	z	+0.746		+0.906			
acd3	r	+0.682	1	+0.355	1		
	z	+0.833		+0.371			
bd3	r	+0.434	2	+0.276	2	+0.372	1
	z	+0.465		+0.283		+0.391	
d3	r	+0.366	2	+0.215	2		
	z	+0.383		+0.218			
Mean	r	+0.498	6	+0.363	6	+0.372	1
	z	+0.546		+0.380		+0.391	
B. <u>Successive-year comparisons</u>							
abe3	r	+0.551	2	+0.390	2	+0.274	1
	z	+0.620		+0.412		+0.281	
abe2	r	+0.562	2	+0.034	2	+0.299	1
	z	+0.636		+0.034		+0.308	
ae3	r	+0.358	2	+0.356	2		
	z	+0.374		+0.372			
ae2	r	+0.455	2	+0.055	2		
	z	+0.492		+0.055			
bce3	r	+0.298	2	+0.208	2	+0.110	1
	z	+0.307		+0.211		+0.110	
ce3	r	+0.237	2	+0.092	2		
	z	+0.242		+0.092			
be2	r	+0.248	2	-0.125	2	-0.061	1
	z	+0.253		-0.126		-0.061	
e2	r	+0.115	2	-0.046	2		
	z	+0.116		-0.046			
Mean	r	+0.340	16	+0.125	16	+0.158	4
	z	+0.354		+0.126		+0.159	

Table 19. Celsius temperatures used for comparison with salmon sizes. All figures are averages for periods ending in the year shown at left. J-D = January through December, A-J = August through July, J-O = June through October. Regressions and correlations are shown for the period of years tabulated ending with the last entry shown. Year 0 for the regression is either 1940 or 1950, as indicated. a = regression intercept at t = 0; b = regression coefficient (degrees per year); r = correlation coefficient; N = number of years in the regression; Mean = mean temperature during the years regressed.

	Station P			Langara		Cape St. James		Amphitrite		Race Rocks	
	J-D	A-J	J-O	J-D	A-J	J-D	A-J	J-D	A-J	J-D	A-J
1 1941	-	-	-	9.65	9.84	-	-	11.46	11.42	-	-
2 1942	-	-	-	9.15	9.34	10.24	10.27	10.63	10.87	9.34	9.46
3 1943	-	-	-	8.82	8.47	9.27	9.47	10.11	10.06	9.07	9.01
4 1944	8.85	(8.61)	12.24	8.75	9.18	10.09	9.89	10.52	10.33	9.31	9.29
5 1945	9.16	8.93	12.10	8.57	8.86	9.38	9.91	10.07	10.76	9.08	9.25
6 1946	9.37	(9.19)	12.21	8.56	8.47	9.22	9.22	9.89	9.91	9.06	9.13
7 1947	-	(9.52)	-	8.63	8.32	9.01	8.82	10.30	9.79	9.13	8.96
8 1948	-	-	-	8.24	8.61	9.05	9.27	9.74	10.11	8.81	9.02
9 1949	8.86	8.62	11.88	8.38	8.06	8.47	8.52	9.44	9.35	8.71	8.62
10 1950	7.58	8.11	9.89	8.10	8.20	8.21	8.23	9.31	9.29	8.47	8.50
11 1951	8.59	7.87	12.01	8.15	8.24	8.89	8.66	9.98	9.85	8.94	8.84
12 1952	7.86	8.04	10.87	8.49	8.19	8.83	8.79	9.94	10.01	8.87	8.93
13 1953	7.92	8.12	11.17	8.92	8.80	9.33	9.29	10.62	10.28	9.25	9.06
14 1954	8.79	8.31	11.98	8.24	8.56	-	-	10.36	10.43	8.77	8.97
15 1955	7.81	8.66	9.90	8.00	8.44	8.52	9.02	9.38	10.01	8.32	8.66
16 1956	8.10	7.78	11.16	8.00	7.77	8.67	8.29	9.52	9.29	8.38	8.28
17 1957	9.24	8.70	12.13	8.84	8.22	8.86	8.70	10.38	9.75	8.84	8.57
18 1958	8.28	9.69	11.69	-	9.65	9.91	9.68	11.39	11.63	9.77	9.65
19 1959	8.68	8.52	11.32	8.70	-	9.39	9.62	10.31	10.59	9.27	9.44
20 1960	8.23	8.74	10.94	8.69	8.75	9.25	9.23	10.36	10.01	9.11	9.15

Table 19 (cont'd)

	Station P			Langara		Cape St. James		Amphitrite		Race Rocks	
	J-D	A-J	J-O	J-D	A-J	J-D	A-J	J-D	A-J	J-D	A-J
21 1961	8.31	8.03	11.67	8.89	9.04	9.73	9.63	10.47	11.00	9.29	9.27
22 1962	8.66	8.81	11.49	8.62	8.34	9.01	8.98	10.51	9.78	9.13	8.95
23 1963	8.64	8.69	11.78	9.52	9.26	10.11	9.74	11.27	11.11	9.37	9.27
24 1964	7.74	8.06	10.63	8.44	9.09	9.17	9.83	10.22	11.00	8.90	9.30
25 1965	8.33	7.90	11.43	8.22	8.07	9.01	8.70	10.19	9.75	8.84	8.65
26 1966	8.12	8.54	10.78	8.38	8.38	9.22	9.44	10.36	10.62	9.03	9.05
27 1967	8.40	8.17	11.76	8.84	8.43	9.42	9.23	10.63	10.29	9.00	9.01
28 1968	7.83	8.22	10.65	8.69	8.92	9.18	9.28	10.23	10.55	8.87	8.98
29 1969	7.70	7.40	10.67	8.43	8.36	9.08	9.08	10.32	10.17	8.69	8.73
30 1970	7.94	7.94	10.20	8.53	8.96	9.38	9.46	10.21	10.56	8.76	8.88
31 1971	7.46	7.79	9.91	7.94	7.89	8.47	8.72	10.00	9.83	8.53	8.47
32 1972	8.54	7.78	11.57	7.78	7.56	8.62	8.27	9.77	9.87	8.52	8.54
33 1973	8.13	8.37	10.74	8.39	8.50	8.75	9.07	10.08	10.06	8.74	8.73
34 1974	8.34	7.98	11.20	8.66	8.32	9.03	8.60	10.21	9.99	-	-
35 1975	-	-	-	7.98	8.42	8.34	8.80	9.97	10.00	-	-
t=0	1940	1940	1940	1940	1940	1940	1940	1940	1940	1940	1940
a	8.833	8.912	11.931	8.777	8.832	9.36	9.36	10.253	10.284	9.096	9.115
b	-0.0256	-0.02816	-0.0359	-0.01331	-0.01439	-0.01250	-0.01293	-0.00111	-0.00259	-0.00878	-0.00902
r	-0.451*	-0.440*	-0.431*	-0.330	-0.292	-0.251	-0.252	-0.023	-0.052	-0.257	-0.263
N	29	30	29	34	34	33	33	35	35	32	32
Mean	8.326	8.367	11.240	8.535	8.574	9.125	9.143	10.233	10.238	8.943	8.957
S.D.	-	0.577	-	0.419	0.512	0.502	0.517	0.495	0.508	0.321	0.322

Table 20. Residuals of temperature (degrees Celsius) and salinity (parts per thousand) at Ocean Station P, used for comparison with salmon sizes. All entries are observed values less the value for the same year computed from a linear regression line. Columns 2 and 3 are based on January through December averages; and are respectively the differences from the regression for 1957-74 and 1944-74 (except 1947 and 1948). Columns 4 and 5 are based on annual means for August 1 through July 31, the entry being positioned in the later year of the two. Column 5 is the mean of entries in column 4 for the current year, the previous year, and 2 years earlier. Column 6 is based on January through December means. Column 7 is the mean of the current year in column 6 and the previous year.

1	2	3	4	5	6	7
	Temperature					
	Jan-Dec		Aug-July		Salinity (Jan-Dec)	
Year	Short series	Long series	Single year	3-year mean	Single year	2-year mean
1944		+0.12	-0.19			
1945		+0.46	+0.16			
1946		+0.69	+0.45	+0.14		
1947		-	+0.81	+0.47		
1948		-	-	(+0.55)		
1949		+0.26	-0.03	(+0.41)		
1950		-1.00	-0.52	(-0.06)		
1951		+0.04	-0.73	-0.43		
1952		-0.67	-0.53	-0.59		
1953		-0.58	-0.43	-0.56		
1954		+0.32	-0.21	-0.39		
1955		-0.64	+0.17	-0.16		
1956		-0.32	-0.68	-0.24		
1957	+0.63	+0.84	+0.27	-0.08	-0.07	
1958	-0.28	-0.09	+1.28	+0.29	+0.04	-0.015
1959	+0.16	+0.33	+0.14	+0.56	+0.13	+0.085
1960	-0.25	-0.09	+0.39	+0.60	+0.05	+0.090
1961	-0.13	+0.02	-0.29	+0.08	+0.08	+0.065
1962	+0.26	+0.39	+0.52	+0.22	-0.12	-0.020
1963	+0.28	+0.40	+0.43	+0.23	-0.12	-0.120
1964	-0.58	-0.48	-0.18	+0.27	+0.05	-0.035
1965	+0.06	+0.14	-0.31	-0.02	-0.01	+0.020
1966	-0.11	-0.05	+0.36	-0.04	-0.03	-0.020
1967	+0.21	+0.26	+0.02	+0.02	-0.04	-0.035
1968	-0.32	-0.29	+0.10	+0.16	-0.09	-0.065
1969	-0.41	-0.39	-0.70	-0.19	-0.05	-0.070
1970	-0.13	-0.12	-0.14	-0.25	+0.02	-0.015
1971	-0.57	-0.58	-0.25	-0.36	+0.13	+0.075
1972	+0.56	+0.53	-0.23	-0.21	+0.02	+0.075
1973	+0.19	+0.14	+0.39	-0.03	-0.07	-0.025
1974	+0.44	+0.38	+0.03	+0.06	+0.05	-0.070

Table 21. Linear correlations (r) between the sockeye size index and surface temperature at Station P, and number of observations (N), during 1944 to 1972 (1974 for the Fraser). "Same year" comparisons are between sockeye returning in year n and the mean temperature from August of year n - 1 through July of year n. "Previous year" and "Next earlier year" comparisons are with temperatures 1 year and 2 years, respectively, earlier than the above. "Direct" comparisons are between actual temperatures and fish sizes. "Residuals" comparisons are between the differences between observed figures and those computed from the linear regressions of size and of temperature on time.

	Same year		Previous year		Next earlier year		Three-year mean	
	r	N	r	N	r	N	r	N
Nass								
Direct	-0.215	28	-0.117	27	-0.139	26	-0.159	27
Residuals	-0.461*	28	-0.359	27	-0.374	26	-0.579**	27
Skeena								
Direct	-0.452*	27	-0.488*	26	-0.442*	25	-0.650**	26
Residuals	-0.303	27	-0.385*	26	-0.349	25	-0.386*	26
Owikenno								
Direct	-0.340	28	-0.300	27	-0.443*	26	-0.510**	27
Residuals	-0.284	28	-0.301	27	-0.123	26	-0.553**	27
Fraser								
Direct	-0.058	30	-0.378*	29	-0.265	28	-0.293	29
Residuals	-0.154	30	-0.473**	29	-0.340	28	-0.472**	29

Table 22. Correlations between residuals of weight of sockeye caught by gillnets and residuals of ocean surface temperature, for four temperature stations, 1951-75. Temperatures are the August-July means for the 12-month period ending in the year of the sockeye catch (S), the previous year (P), and the year before that (A). The number of years is 25 for Langara and Amphitrite, and 24 for Cape St. James and Station P.

Region Area	Nass 3	Skeena 4	Owiken 9	Fraser 29A+B
Langara				
S	+0.007	+0.027	+0.223	-0.224
P	-0.091	+0.084	-0.156	-0.021
A	-0.552**	-0.433*	-0.437*	-0.289
Cape St. James				
S	-0.084	+0.061	+0.112	-0.329
P	-0.282	-0.075	-0.318	-0.257
A	-0.453*	-0.321	-0.282	-0.342
Amphitrite				
S	+0.014	+0.186	+0.198	-0.165
P	-0.218	-0.008	-0.252	-0.273
A	-0.508*	-0.415*	-0.247	-0.364
Station P				
S	-0.069	+0.055	+0.047	-0.171
P	-0.243	-0.082	-0.051	-0.423*
A	-0.188	-0.106	-0.031	-0.402*

Table 23. Mean weights in pounds of chum and sockeye salmon in several statistical Areas.

Year	Area 3 Seined		Area 4 Gillnetted		Area 9 Gillnetted		Area 20 Seined		Area 29AB Gillnetted	
	Chums	Sockeye	Chums	Sockeye	Chums	Sockeye	Chums	Sockeye	Chums	Sockeye
1951	12.52	6.36	12.54	6.28	12.19	6.85	12.83	7.32	11.79	7.29
1952	14.85	6.00	14.23	5.99	14.76	6.26	16.97	7.02	13.33	7.10
1953	15.20	6.62	13.84	6.44	13.96	5.80	12.02	6.33	12.34	6.27
1954	14.62	7.36	16.13	6.96	16.51	6.19	15.26	7.40	13.37	7.26
1955	13.23	5.69	13.81	6.02	15.52	5.83	12.57	6.14	12.44	5.99
1956	13.18	5.94	12.52	5.90	13.76	7.19	13.12	6.45	12.27	6.42
1957	13.04	5.52	15.11	5.76	12.96	5.04	13.65	4.83	12.13	5.25
1958	13.57	6.39	14.18	6.41	16.36	6.42	15.20	6.18	11.21	6.21
1959	14.05	5.77	14.63	6.13	14.35	5.73	11.15	5.31	11.82	5.45
1960	14.35	5.08	14.53	5.49	13.84	5.32	10.41	5.43	11.01	5.42
1961	13.27	5.85	14.93	5.87	13.91	5.84	11.89	5.86	12.31	5.85
1962	12.89	5.91	13.88	6.29	14.45	4.95	11.25	6.64	11.84	6.47
1963	13.37	4.89	11.56	5.63	11.74	6.29	11.44	5.74	11.82	5.76
1964	12.18	6.37	12.78	6.46	11.74	6.72	11.60	5.52	13.02	5.90
1965	11.84	5.14	11.95	5.53	12.27	4.72	9.85	5.12	10.25	5.90
1966	12.07	5.38	13.84	6.26	12.98	6.21	11.08	6.87	11.80	6.52
1967	11.81	5.89	13.21	5.97	13.12	4.42	10.19	5.99	11.15	5.65
1968	13.24	6.73	13.73	6.92	13.78	7.07	11.95	5.59	12.12	5.77
1969	12.13	5.31	12.28	5.99	9.88	5.33	11.65	5.56	11.34	5.73
1970	10.31	5.35	10.58	5.82	11.95	5.67	10.13	6.40	11.42	6.32
1971	10.89	5.54	11.05	5.97	12.32	5.33	8.22	6.26	9.65	6.19
1972	11.75	5.91	12.14	6.60	12.96	4.97	10.86	5.87	11.44	6.00
1973	12.81	5.88	12.46	6.23	13.73	7.18	11.55	5.83	12.12	5.92
1974	12.36	6.14	13.58	6.47	15.39	6.91	11.12	6.75	12.00	6.67
1975	12.33	5.35	10.57	5.64	10.19	5.30	10.31	5.58	10.40	5.96
1976	11.06	5.54	12.82	5.35	14.12	5.89	10.58	5.99	13.01	6.18
1977	12.50	6.23	12.78	6.36	12.72	6.38	10.78	6.13	11.97	6.33
1978	11.82	6.09	11.40	7.00	13.84	7.67	11.31	6.75	11.98	6.49
1979	12.55	5.30	11.42	5.44	10.93	4.95	10.39	6.09	11.28	5.97
1980	13.18	5.55	10.01	6.21	10.30	-	10.32	5.48	11.83	5.61

Table 24. Mean weights in pounds of sockeye and pink salmon in several statistical Areas.

Year	Area 3			Area 4			Area 9			Area 10			Area 20			Area 29AB		
	Seined			Seined Gillnetted			Gillnetted			Gillnetted			Seined			Gillnetted		
	Pinks	Sockeye		Pinks	Sockeye		Pinks	Sockeye		Pinks	Sockeye		Pinks	Sockeye		Pinks	Sockeye	
1951	4.76	6.36	-	-	6.28		5.76	6.85		5.49	7.21		6.37	7.32		6.28	7.29	
1953	5.69	6.62	5.97	5.97	6.44		5.57	5.80		5.41	5.87		5.92	6.33		6.11	6.27	
1955	5.08	5.69	4.89	4.89	6.02		5.47	5.83		5.46	6.20		6.39	6.14		6.41	5.99	
1957	4.87	5.52	4.81	4.81	5.76		5.27	5.04		5.00	5.79		5.51	4.83		5.66	5.25	
1959	4.96	5.77	4.73	4.73	6.13		5.21	5.73		5.24	6.14		5.24	5.31		5.49	5.45	
1961	5.55	5.85	5.97	5.97	5.87		6.05	5.84		5.57	6.17		6.82	5.86		a	5.85	
1963	4.41	4.89	4.64	4.64	5.63		5.06	6.29		5.21	6.47		5.07	5.74		5.39	5.76	
1965	3.60	5.14	-	-	5.53		4.72	4.72		5.09	5.40		6.33	5.12		6.35	5.90	
1967	4.94	5.89	4.43	4.43	5.97		5.06	4.42		4.78	5.07		5.32	5.99		5.56	5.65	
1969	4.40	5.31	4.04	4.04	5.99		5.00	5.33		5.31	6.08		5.79	5.56		6.23	5.73	
1971	3.83	5.54	3.93	3.93	5.97		5.00	5.33		5.19	6.22		5.00	6.26		5.14	6.19	
1973	3.36	5.88	3.25	3.25	6.23		4.43	7.18		4.64	6.92		5.37	5.83		5.55	5.92	
1975	3.48	5.35	4.01	4.01	5.64		4.78	5.30		4.71	6.24		6.00	5.58		5.90	5.96	
1977	5.12	6.23	4.85	4.85	6.36		5.24	6.38		5.24	5.98		5.79	6.13		5.75	6.33	
1979	4.32	5.30	4.48	4.48	5.44		4.31	4.95		4.52	6.26		4.85	6.09		5.12	5.97	
1952	-	6.00	4.22	4.22	5.99		4.55	6.26		4.67	7.14		-	7.02		4.79	7.10	
1954	4.79	7.36	4.94	4.94	6.96		4.62	6.19		4.97	6.32		-	7.40		-	7.26	
1956	3.64	5.94	3.59	3.59	5.90		4.36	7.19		4.67	7.13		-	6.45		5.29	6.42	
1958	5.24	6.39	-	-	6.41		4.69	6.42		4.68	6.59		-	6.18		5.08	6.21	
1960	3.66	5.08	3.53	3.53	5.49		4.25	5.32		4.36	5.98		-	5.43		-	5.42	
1962	3.99	5.91	3.68	3.68	6.29		3.99	4.95		4.09	5.41		4.76	6.64		-	6.47	
1964	3.73	6.37	3.77	3.77	6.46		3.94	6.72		4.03	6.66		-	5.52		-	5.90	
1966	4.18	5.38	-	-	6.26		4.18	6.21		4.43	6.73		4.35	6.87		-	6.52	
1968	2.80	6.73	2.80	2.80	6.92		3.35	7.07		3.82	6.82		-	5.59		-	5.77	
1970	3.64	5.35	4.01	4.01	5.82		4.09	5.67		4.35	6.25		4.46	6.40		5.12	6.32	

Table 24 (cont'd)

Year	Area 3		Area 4		Area 9		Area 10		Area 20		Area 29AB	
	Pinks	Sockeye	Pinks	Sockeye	Pinks	Sockeye	Pinks	Sockeye	Pinks	Sockeye	Pinks	Sockeye
1972	2.46	5.91	2.56	6.60	3.29	4.97	4.01	5.40	3.54	5.87	-	6.00
1974	3.14	6.14	3.34	6.47	3.69	6.91	4.25	7.23	-	6.75	-	6.67
1976	3.36	5.84	2.77	5.35	3.89	5.69	4.03	6.37	-	5.99	-	6.18
1978	3.18	6.09	3.40	7.00	3.68	7.67	4.21	7.47	-	6.75	-	6.49
1980	3.88	5.55	3.46	6.21	3.37	-	-	5.90	-	5.48	-	5.61

^aSee note to Table 25.

Table 25. Mean weight in pounds of pink salmon caught in the year shown at left, and of sockeye salmon caught in the year at right, with their regressions on time in years. The last 3 rows show the relation between sockeye and pinks in terms of the correlation coefficient (r), the ordinary regression of sockeye size on pink size (b), and the geometric mean regression of sockeye size on pink size (GMR).

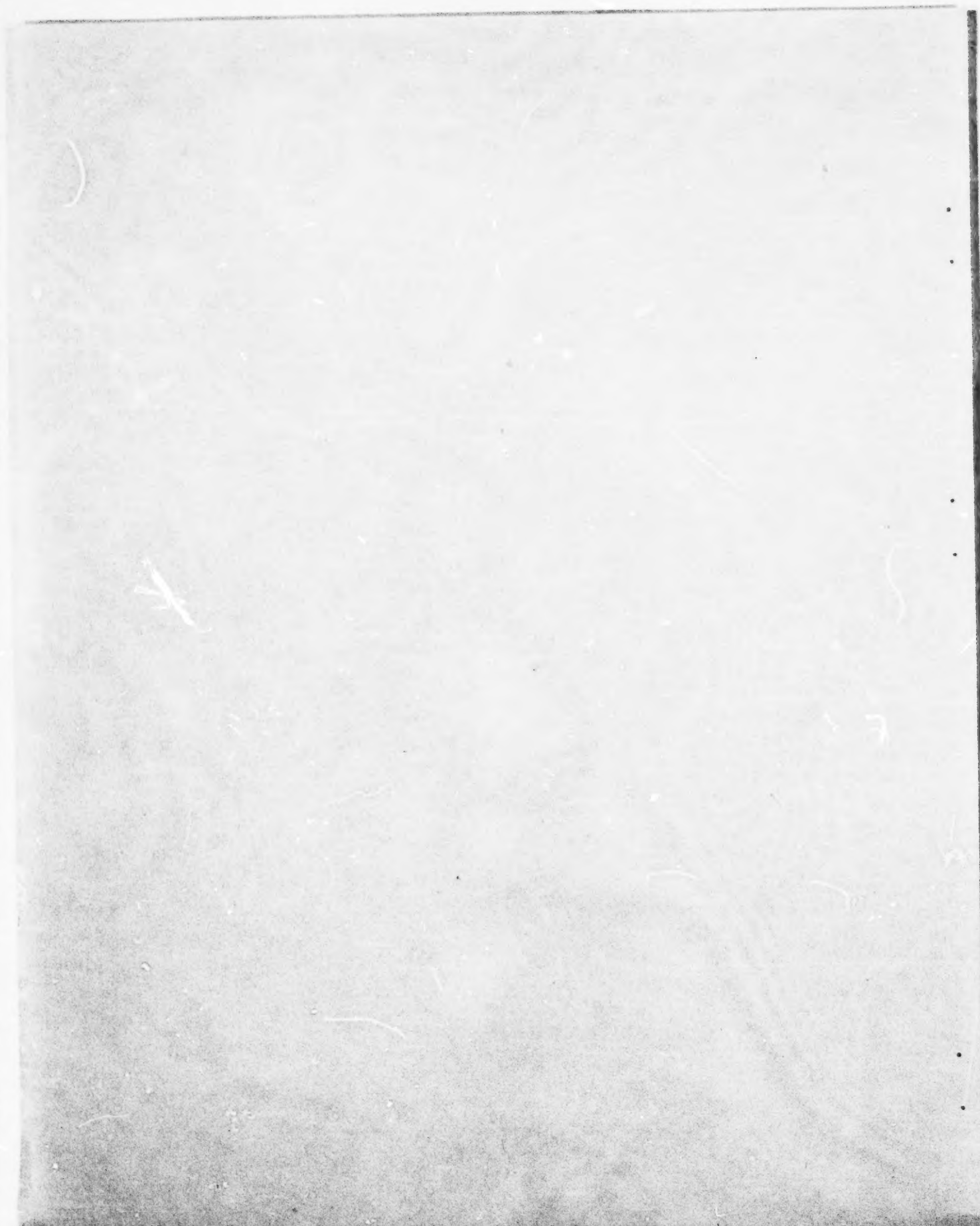
Pink year	Area 20 Seined		Area 29AB Gillnetted		Sockeye year
	Pinks	Sockeye	Pinks	Sockeye	
1951	6.37	7.02	6.28	7.10	1952
1953	5.92	7.40	6.11	7.26	1954
1955	6.39	6.45	6.41	6.42	1956
1957	5.51	6.18	5.66	6.21	1958
1959	5.24	5.43	5.49	5.42	1960
1961	6.82	6.64	a	(6.47)	1962
1963	5.07	5.52	5.39	5.90	1964
1965	6.33	6.87	6.35	6.52	1966
1967	5.32	5.59	5.56	5.77	1968
1969	5.79	6.40	6.23	6.32	1970
1971	5.00	5.87	5.14	6.00	1972
1973	5.37	6.75	5.55	6.67	1974
1975	6.00	5.99	5.90	6.18	1976
1977	5.79	6.75	5.75	6.49	1978
1979	4.85	5.48	5.12	5.61	1980
N	15	15	14	14	
Mean	5.718	6.289	5.781	6.276	
b(lb/yr)	-0.0294	-0.0246	-0.0240	-0.0230	
r	-0.447	-0.353	-0.505	-0.404	

Relationships between sockeye and pink sizes

r	+0.694**	+0.671**
b(lb/lb)	+0.736	+0.805
GMR(lb/lb)	+1.061	+1.200

aFishing for pinks was restricted because of scarcity, so a larger than usual percentage of the pinks caught were taken in sockeye nets, resulting in the unrepresentative mean weight of 7.38 lb

FIGURES



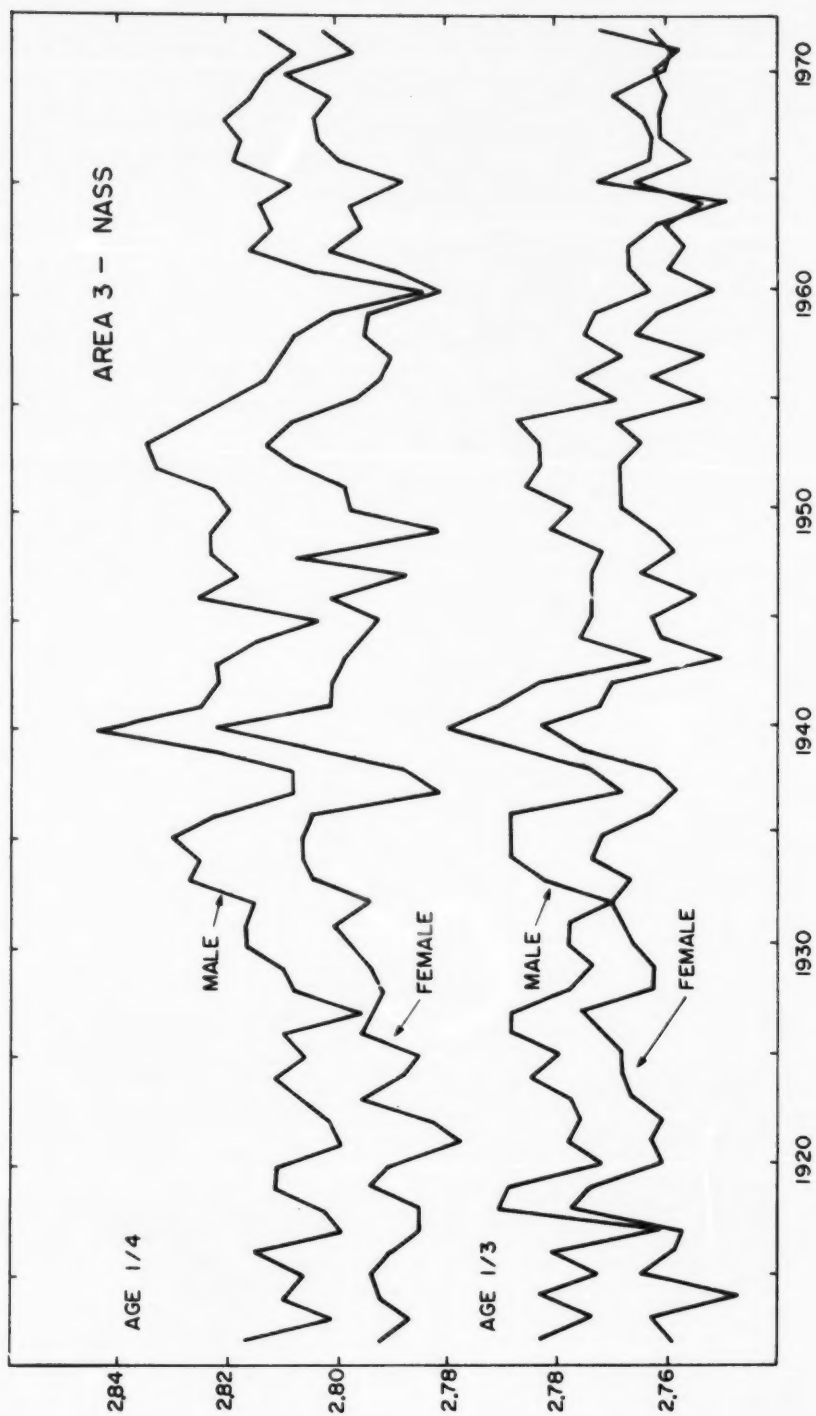


Fig. 1. Trends in the size index for Nass sockeye of life-history types 1/3 and 1/4. The ordinate scale is the base-10 logarithm of mean fork length in millimeters.

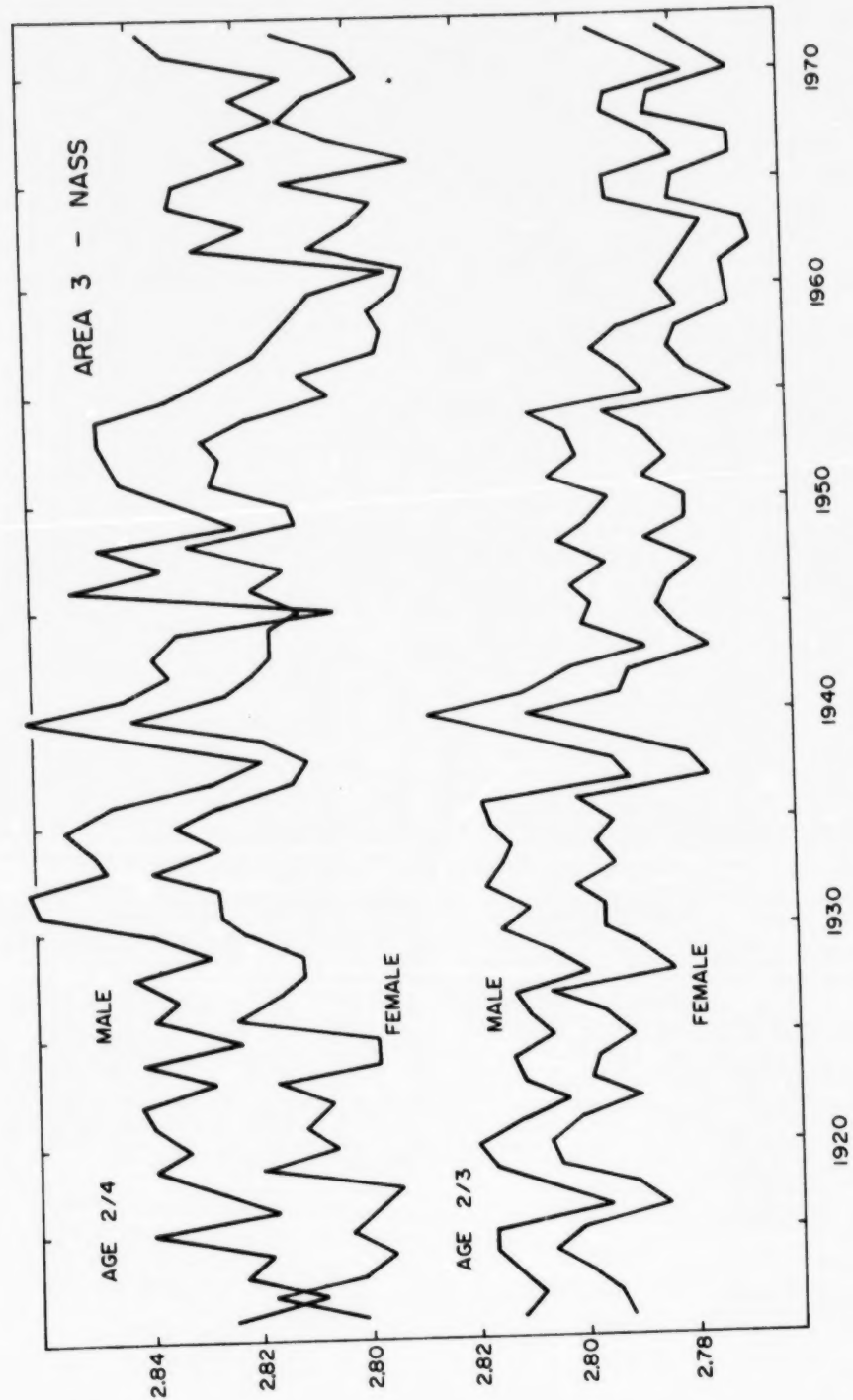


Fig. 2. Size trends of Nass 2/3 and 2/4 sockeye. Scale as in Fig. 1.

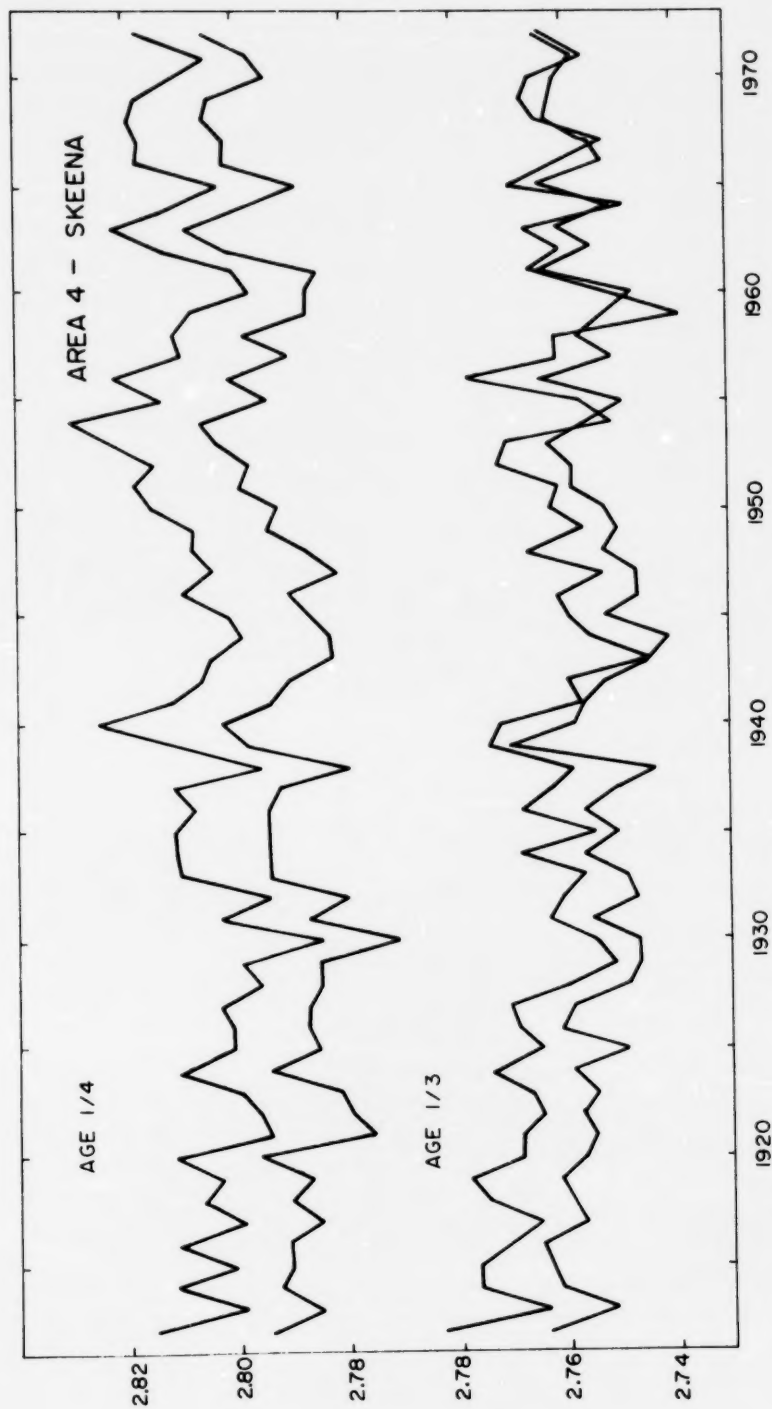


Fig. 3. Size trends of Skeena 1/3 and 1/4 sockeye. Scale as in Fig. 1.

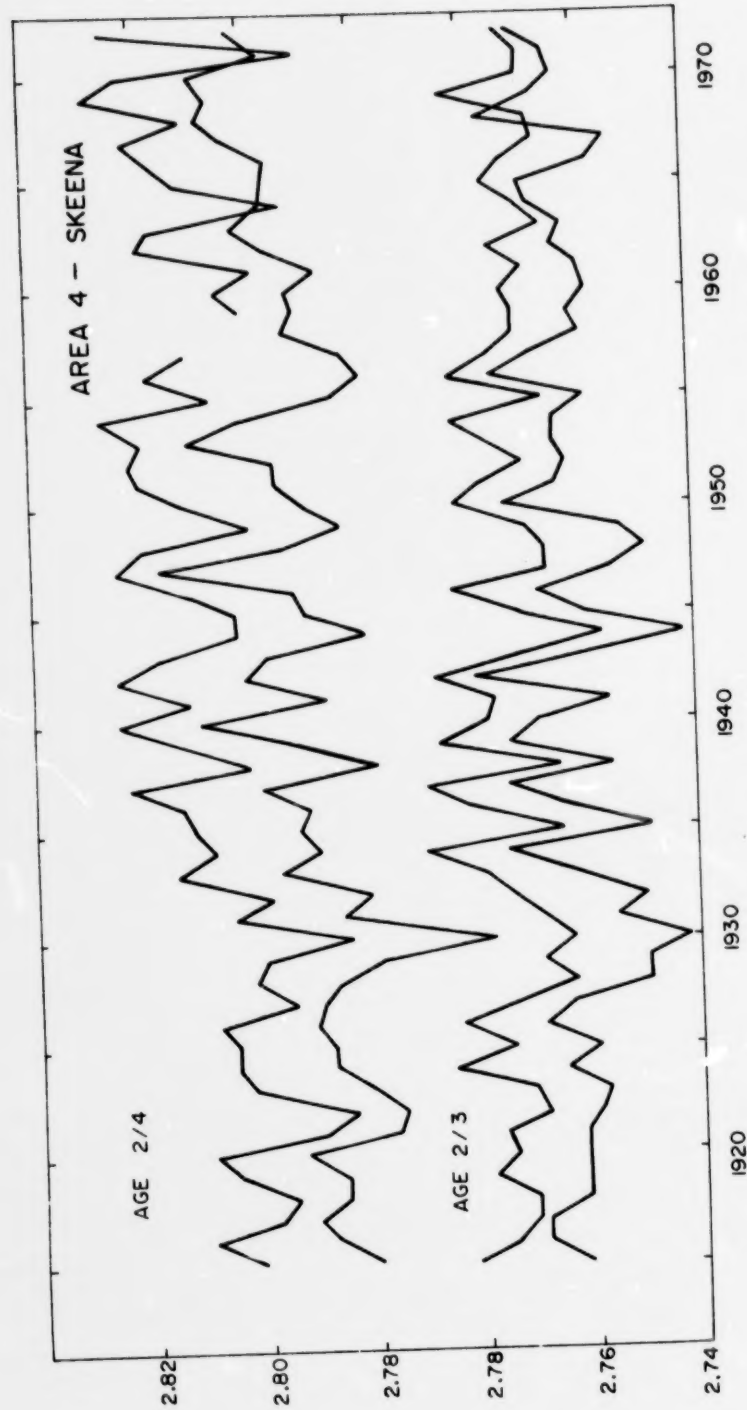


Fig. 4. Size trends of Skeena 2/3 and 2/4 sockeye. Scale as in Fig. 1.

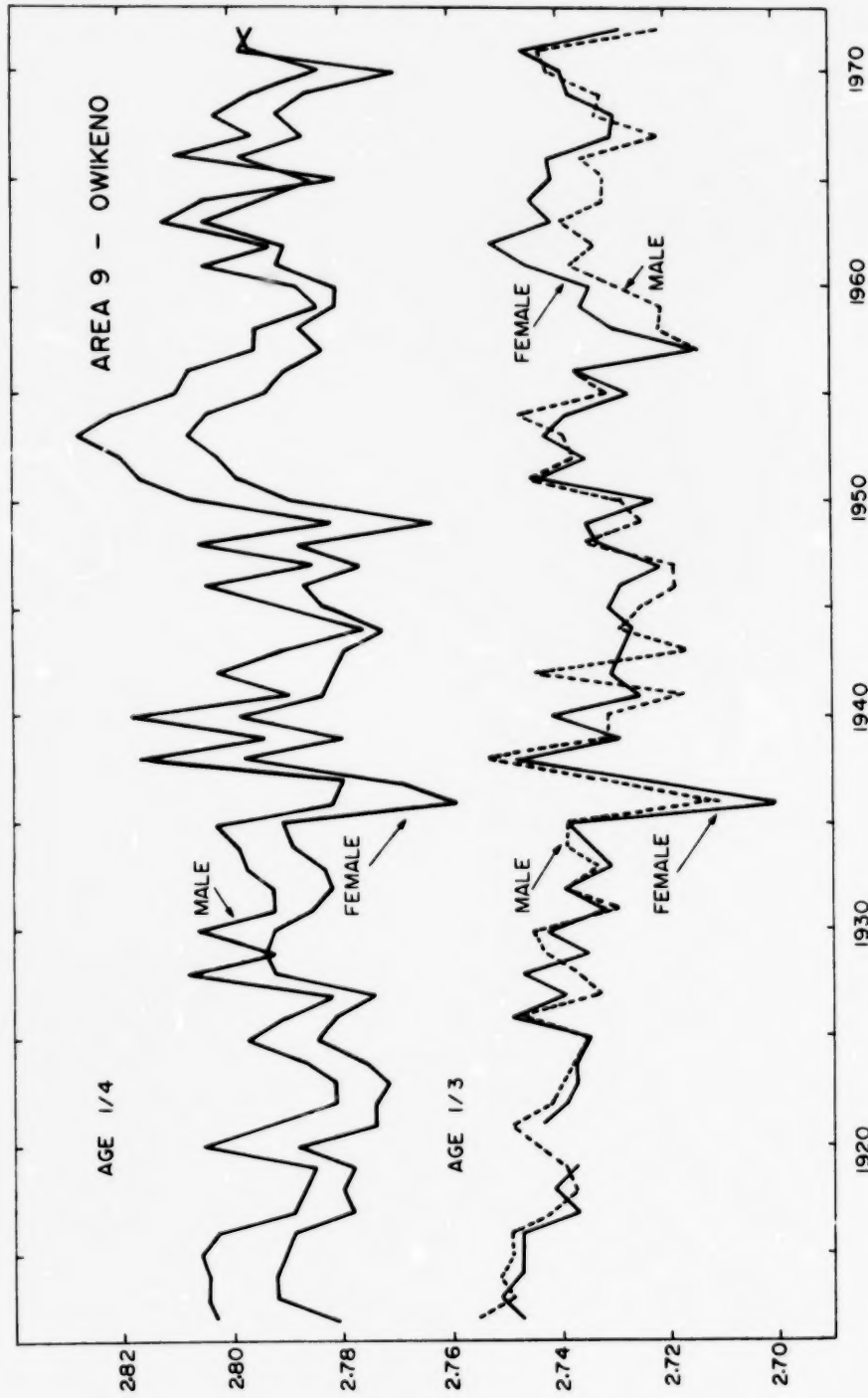


Fig. 5. Size trends in Owikeno 1/3 and 1/4 sockeye. Scale as in Fig. 1.



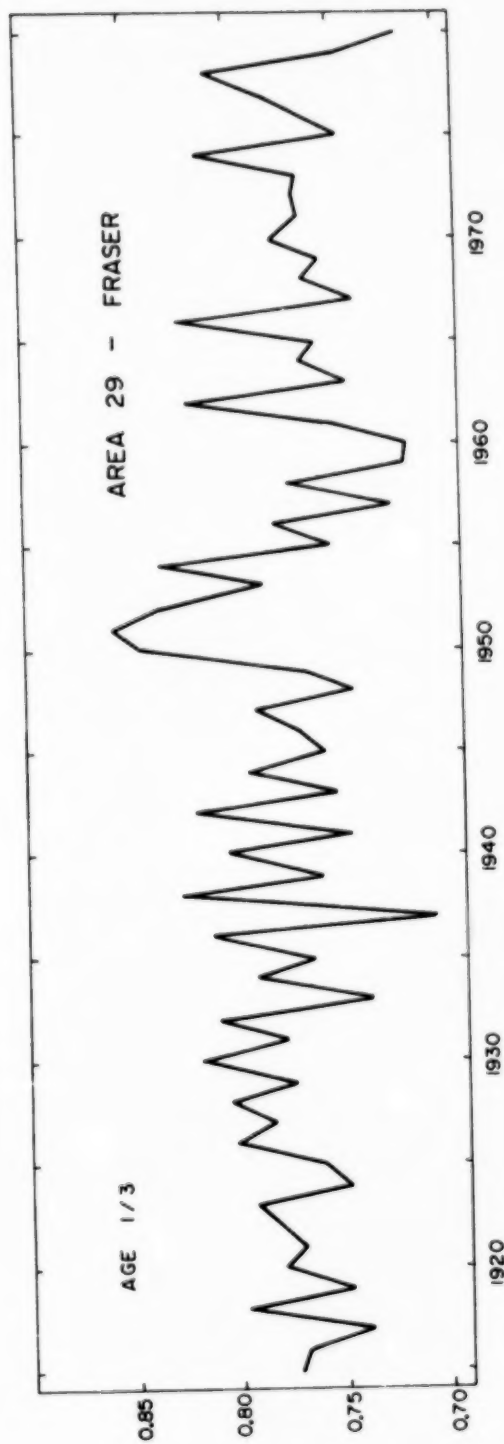


Fig. 6. Size trend in Fraser 1/3 sockeye, sexes combined. The ordinate scale is the base-10 logarithm of weight in pounds.

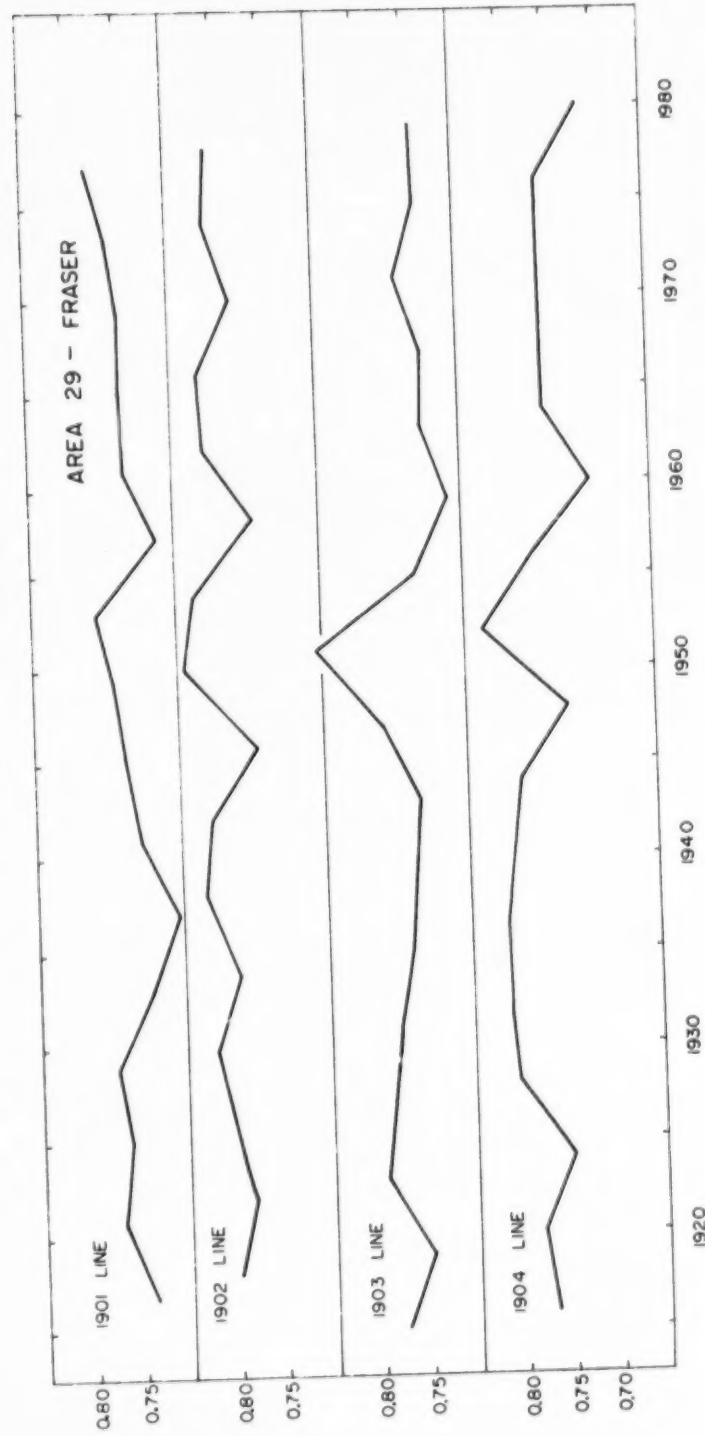


Fig. 7. Size trends in Fraser 1/3 sockeye, by lines. Scale as in Fig. 6.

Fig. 8. Five-year means of percentage representation of the four principal life-history types among Nass sockeye.

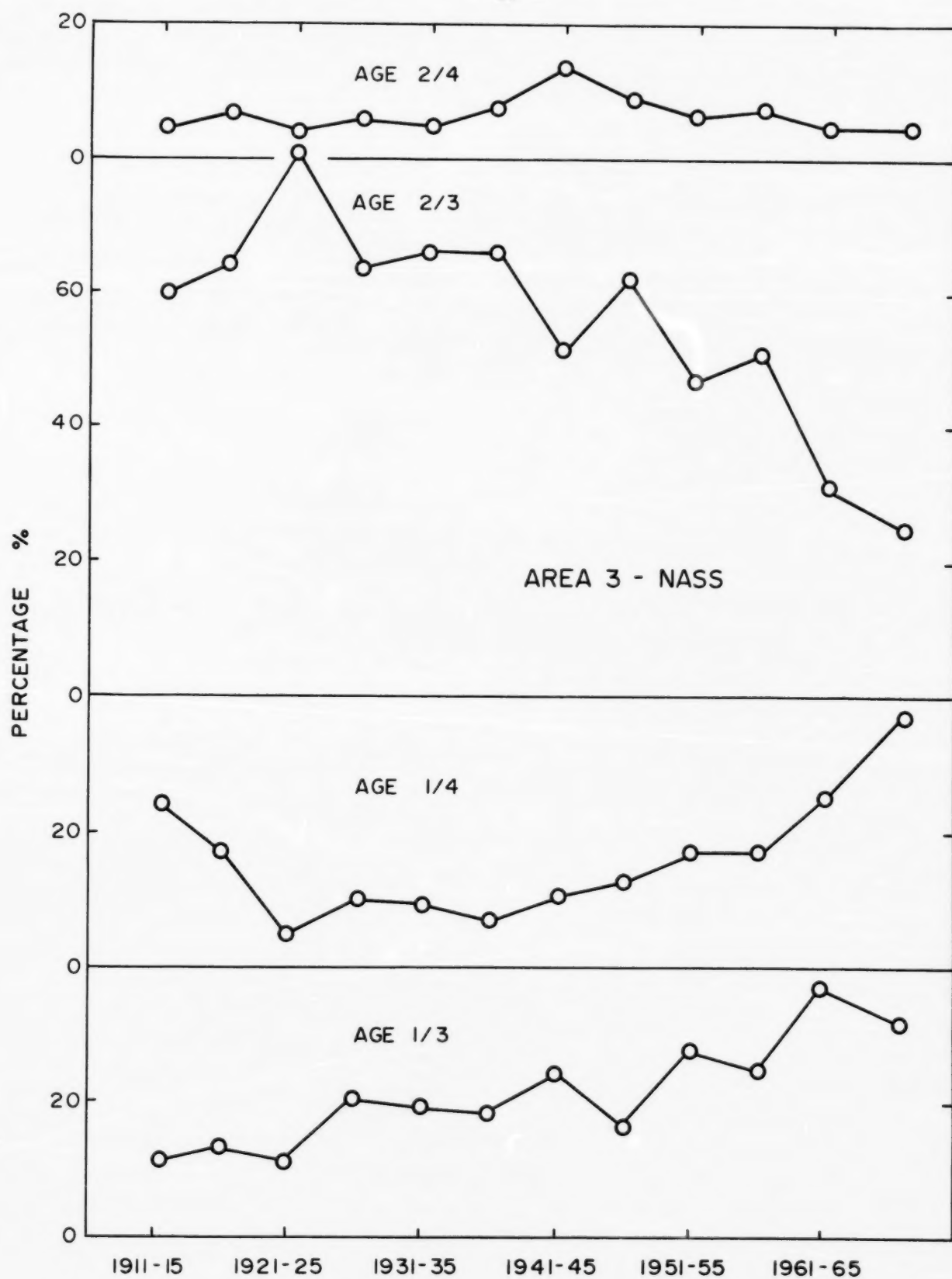


Fig. 9. Five-year means of percentage representation of the four principal life-history types among Skeena sockeye.

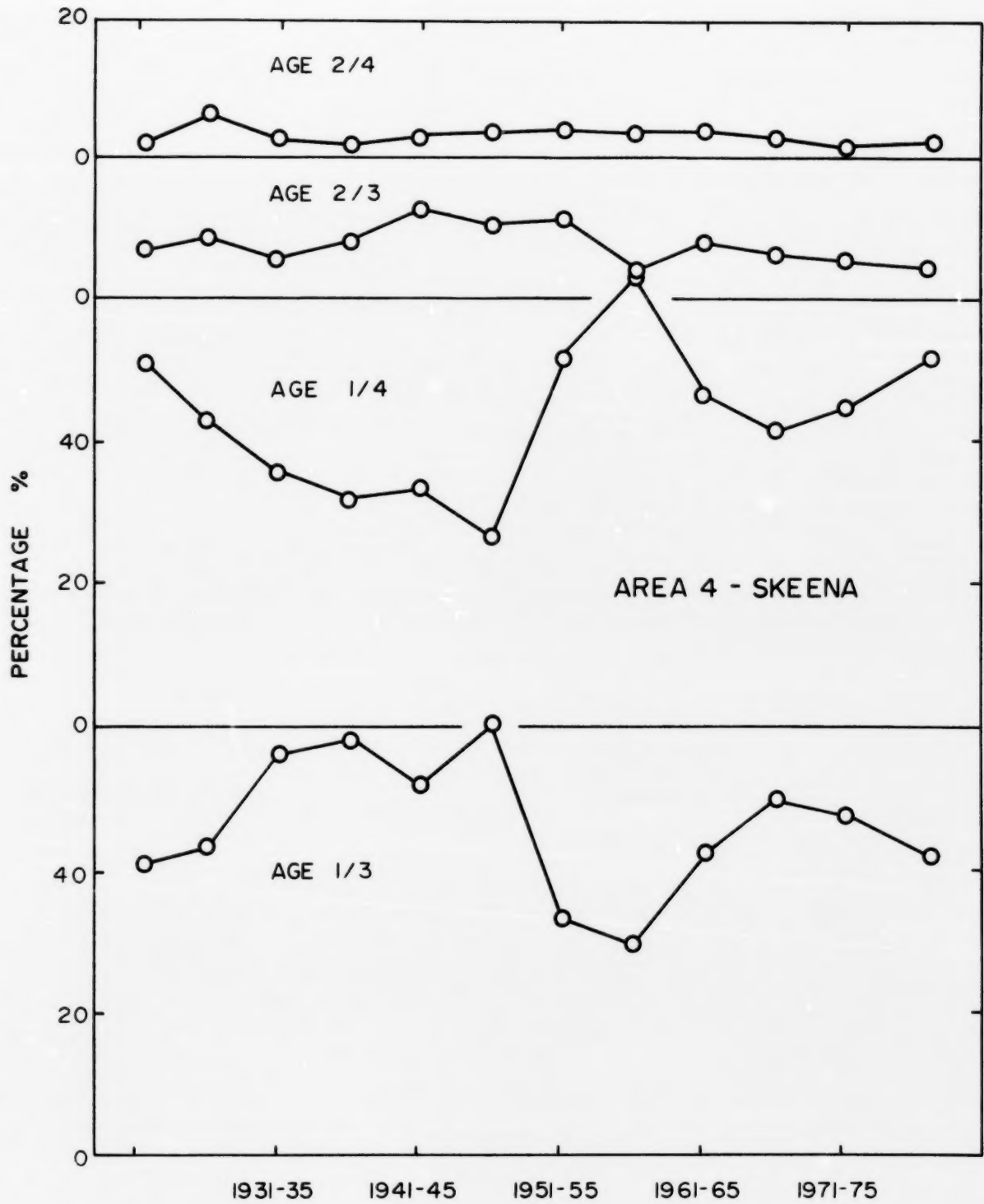


Fig. 10. Five-year means of percentage representation of 2 major and 2 minor life-history types among Owikeno sockeye. Note that a larger scale is used for the 2-freshwater types.

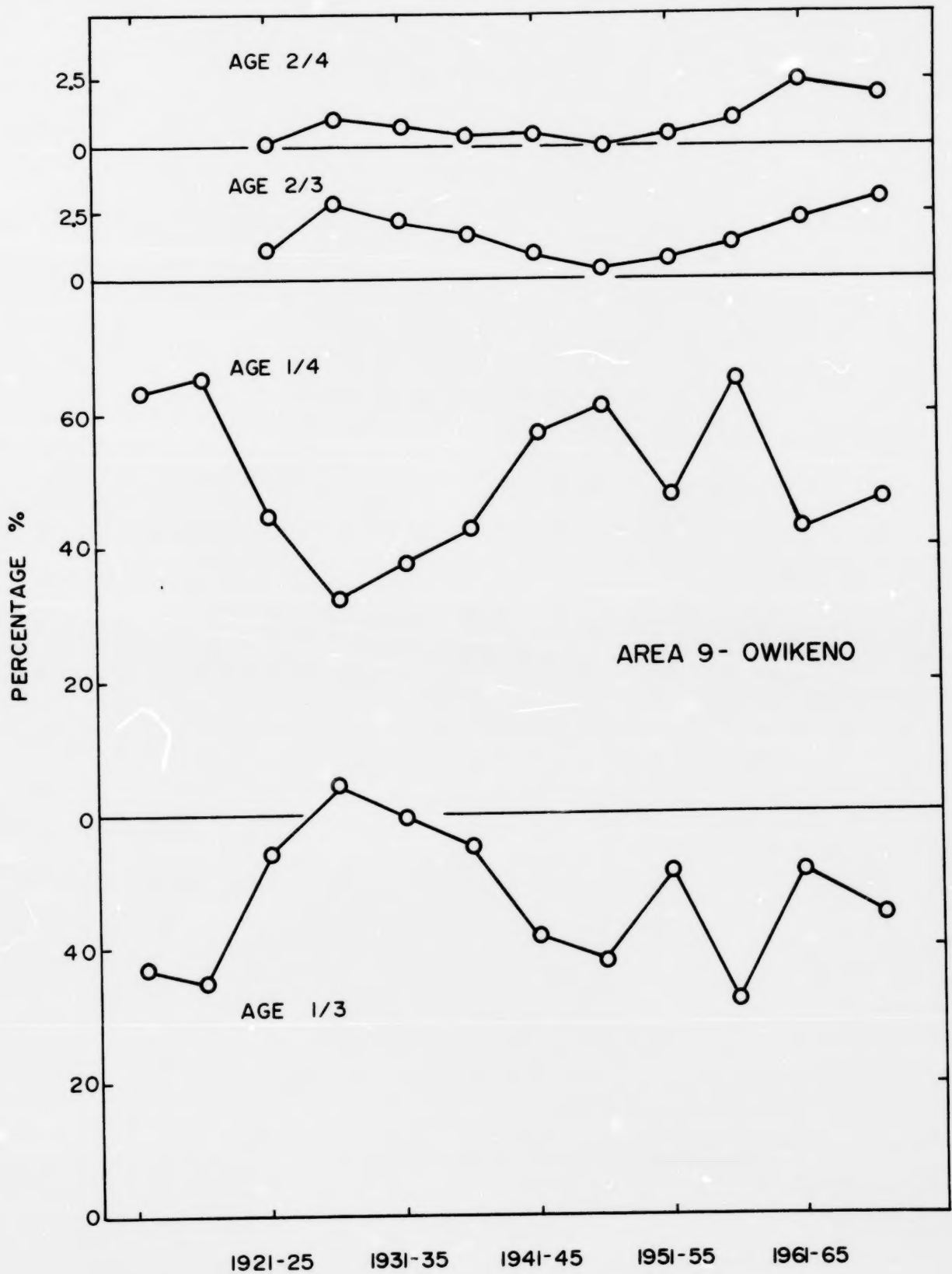


Fig. 11. Top 4 lines: Combined logarithmic size indices for the 4 principal sockeye Areas (see Section 1.4). Bottom line: Mean of monthly mean temperatures at 50°N, 145°W, for 12-month periods ending on July 31 of the year shown, from Table 20.

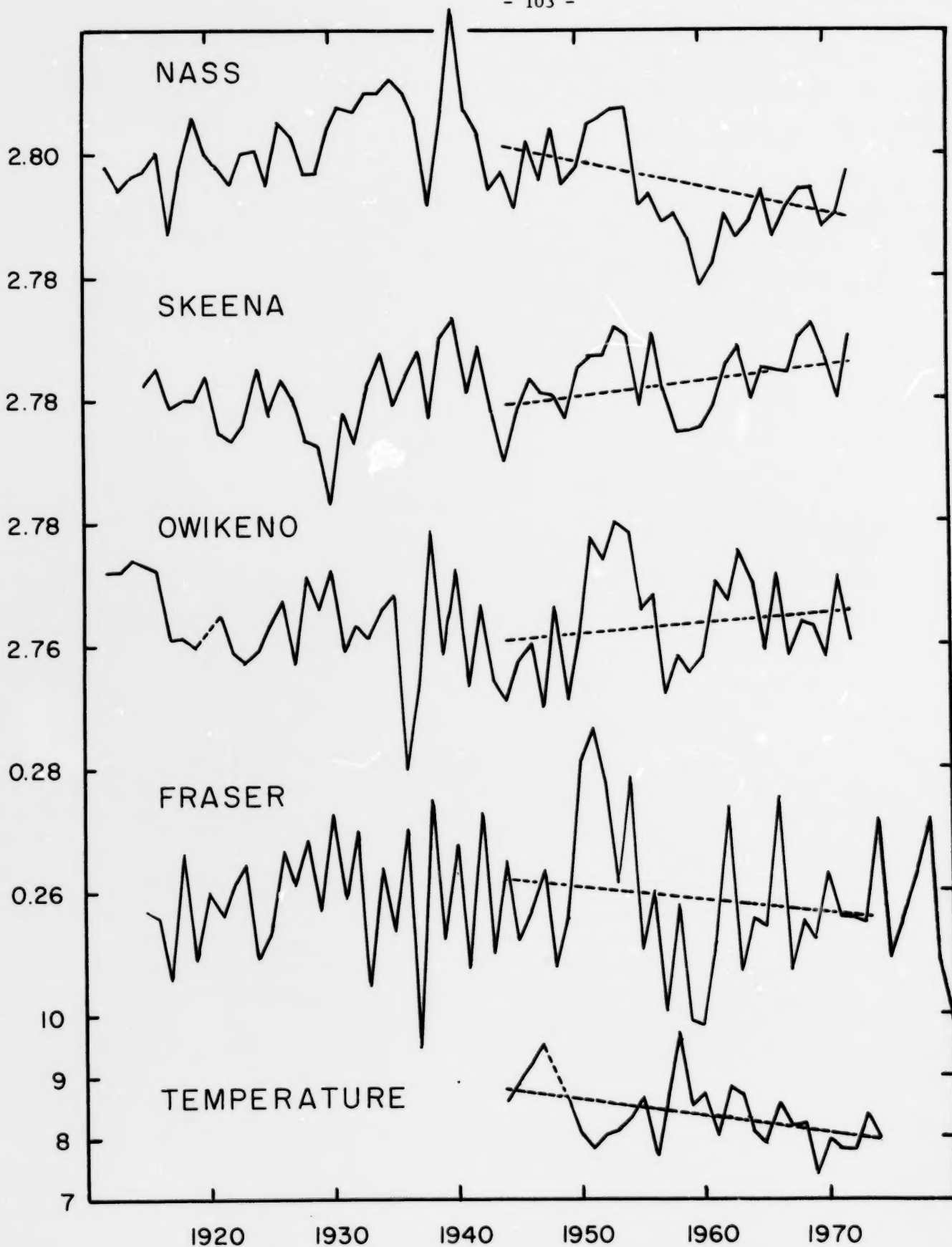


Fig. 12. Mean weight in pounds of sockeye caught by gillnet in 4 Areas.
Regression lines are fitted to the years 1951-75.

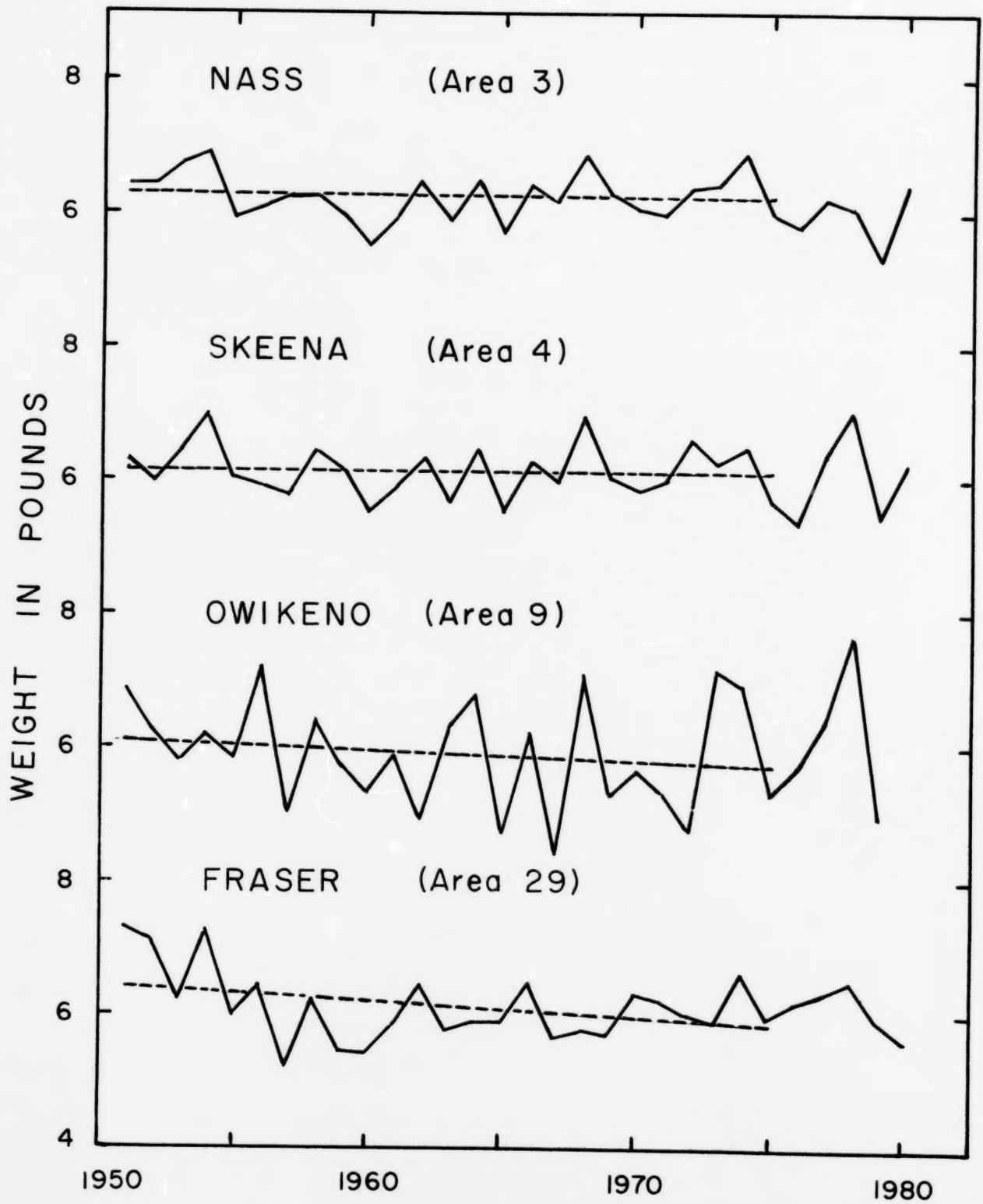
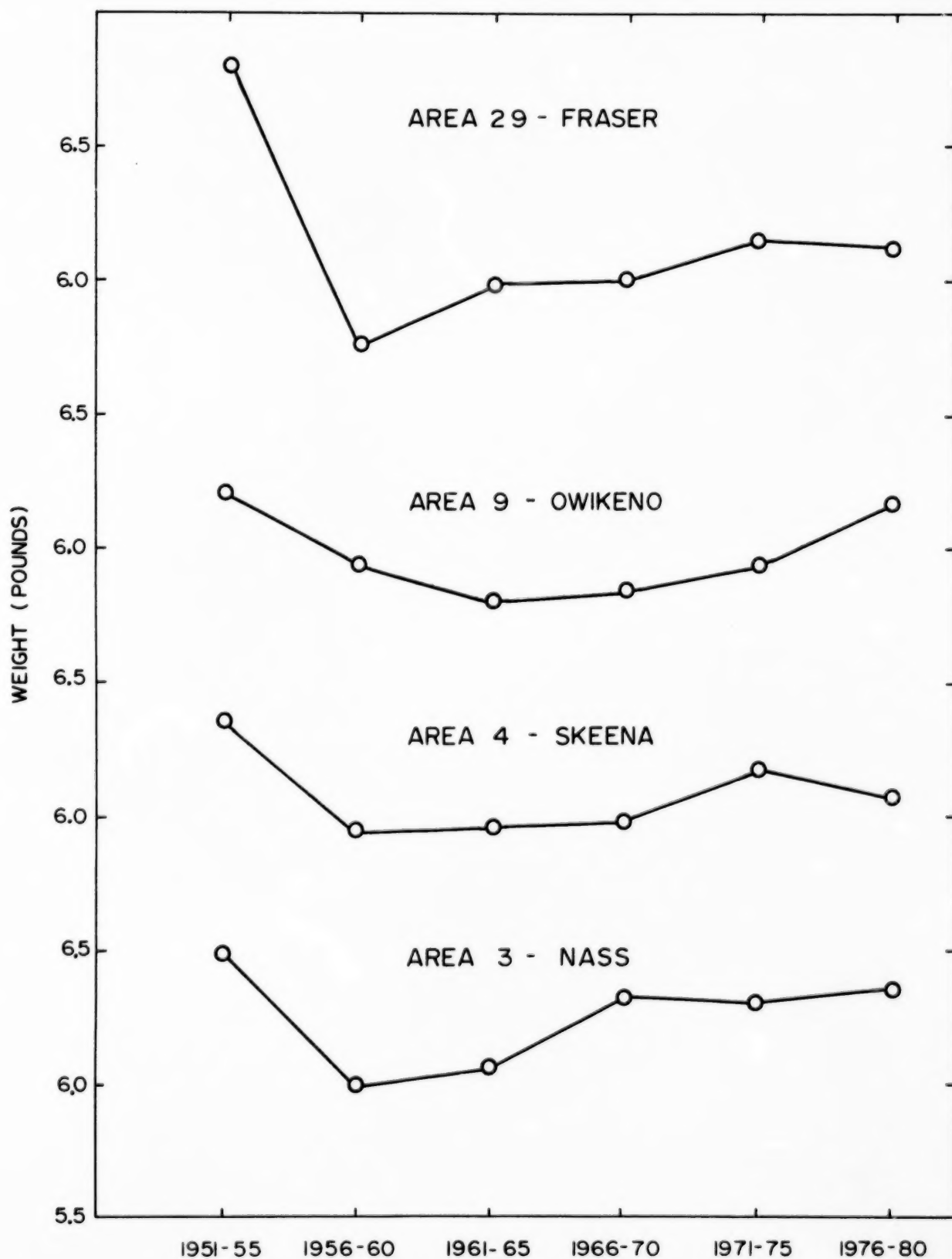


Fig. 13. Five-year mean weight in pounds of sockeye caught by gillnet in 4 Areas.





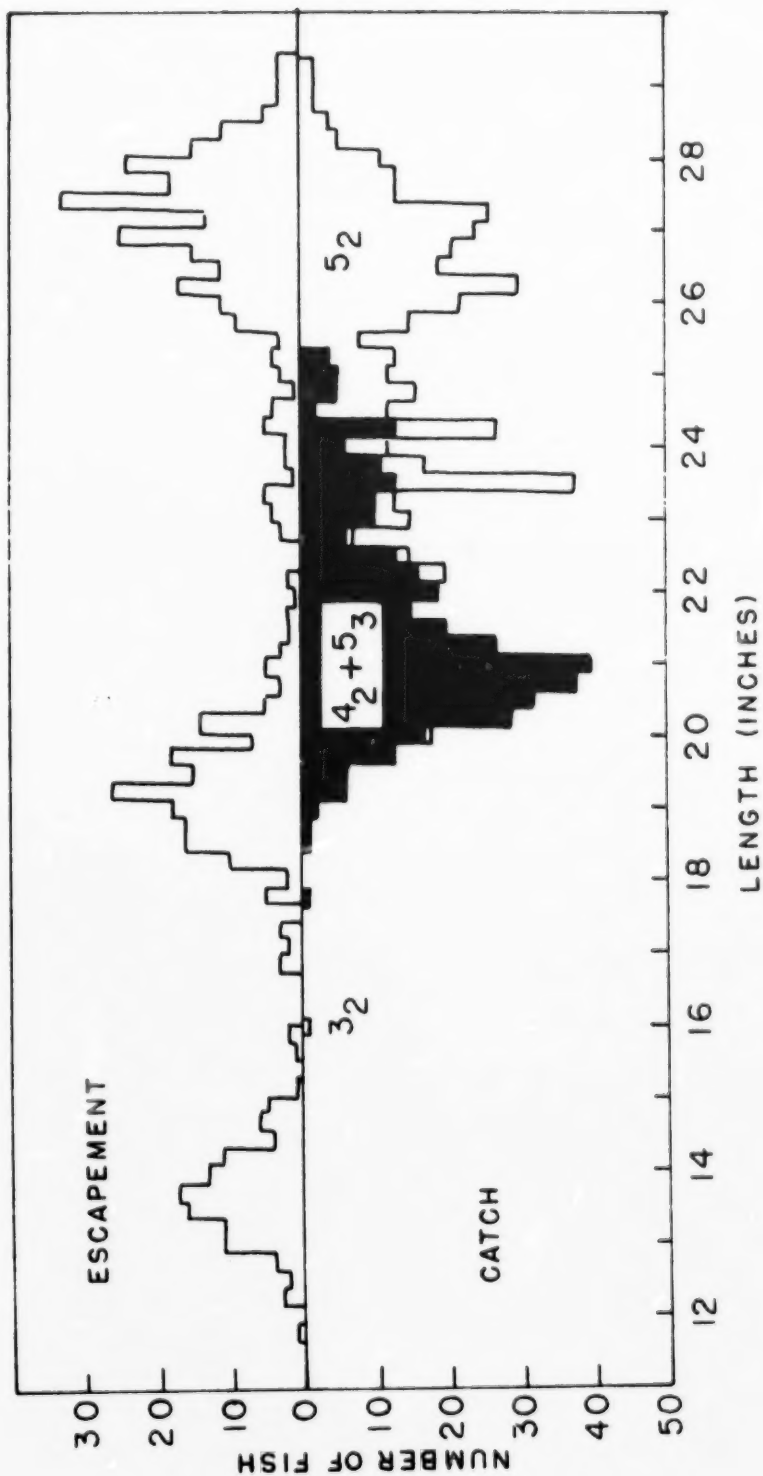


Fig. 14. Mean fork lengths of male Owikeno sockeye in 1952 (1 inch = 25.4 mm). The escapement lengths are reduced by dividing by 1.04 to adjust for lengthening of the nose at maturity. (After Foskett 1958, Fig. 7).

Fig. 15. Five-year means of changes in length of catch samples of Nass sockeye (Area 3). Top panel: Difference in postorbital-hypural (PH) length between sockeye of life-history types 1/4 and 1/3, and between types 2/4 and 2/3, for the sexes separately, in millimetres. Bottom panel: Difference in PH length between males and females for the 4 life-history types, in millimetres.

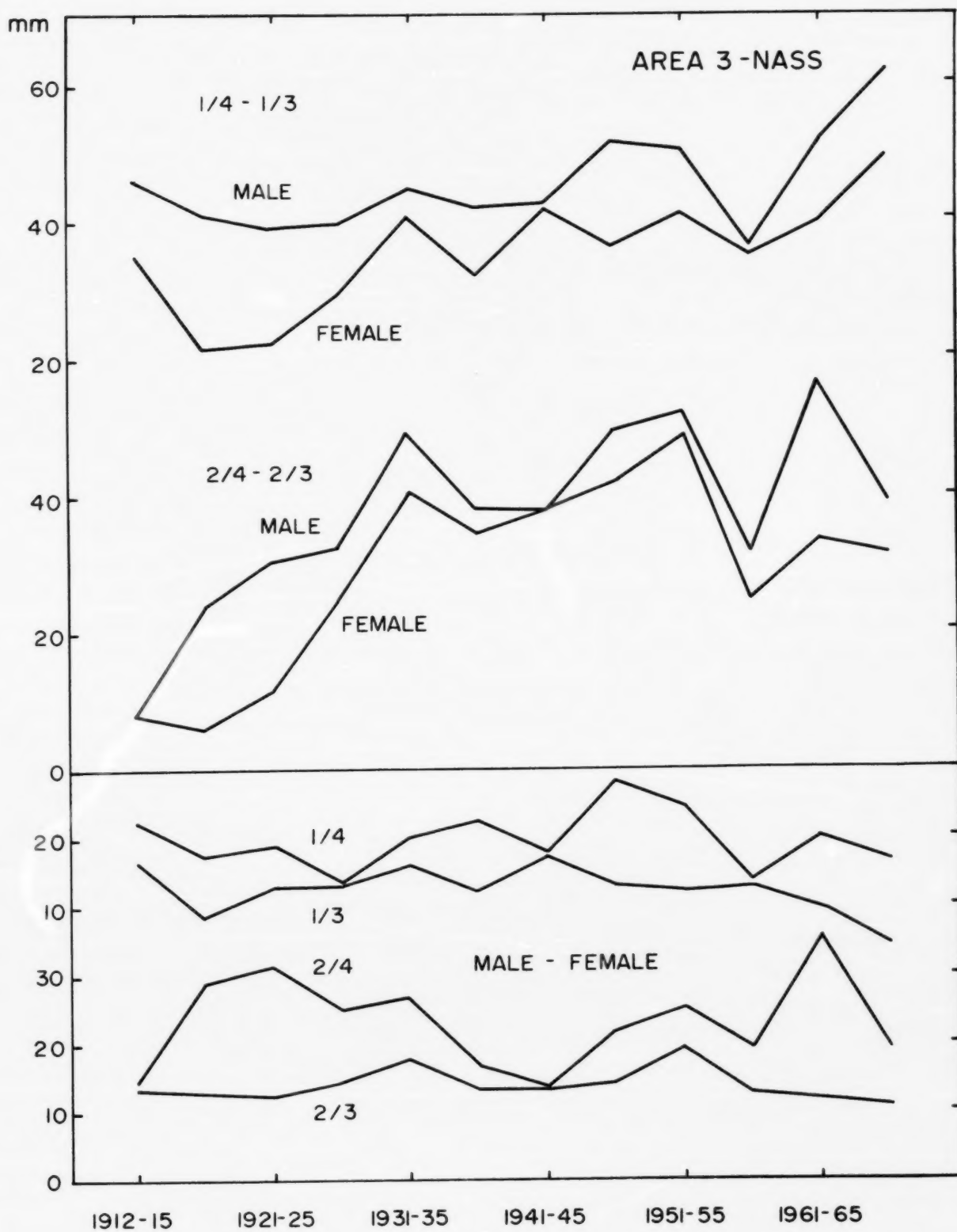


Fig. 16. Five-year changes in length of catch samples of Skeena sockeye (Area 4). Details as in Fig. 15.

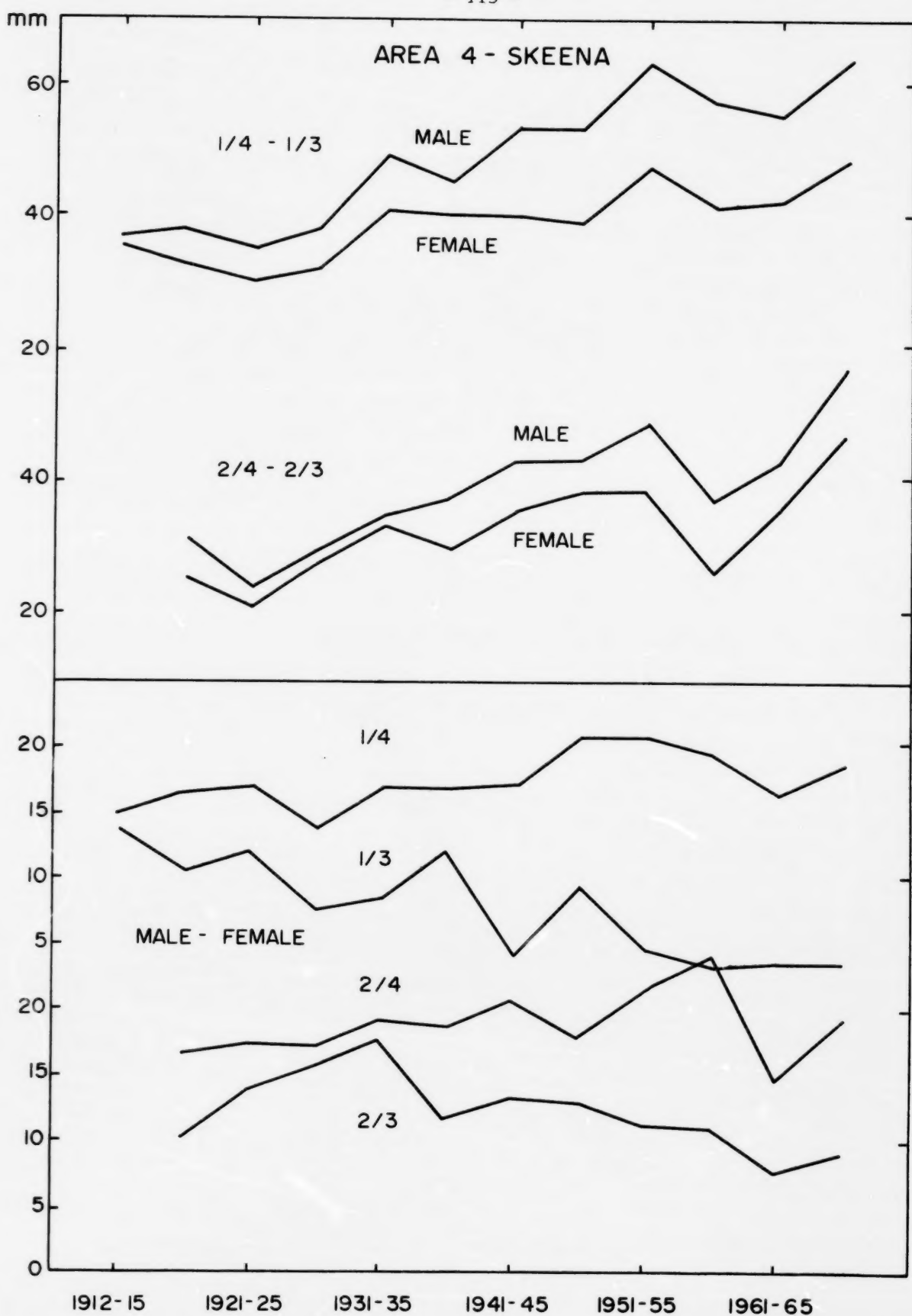
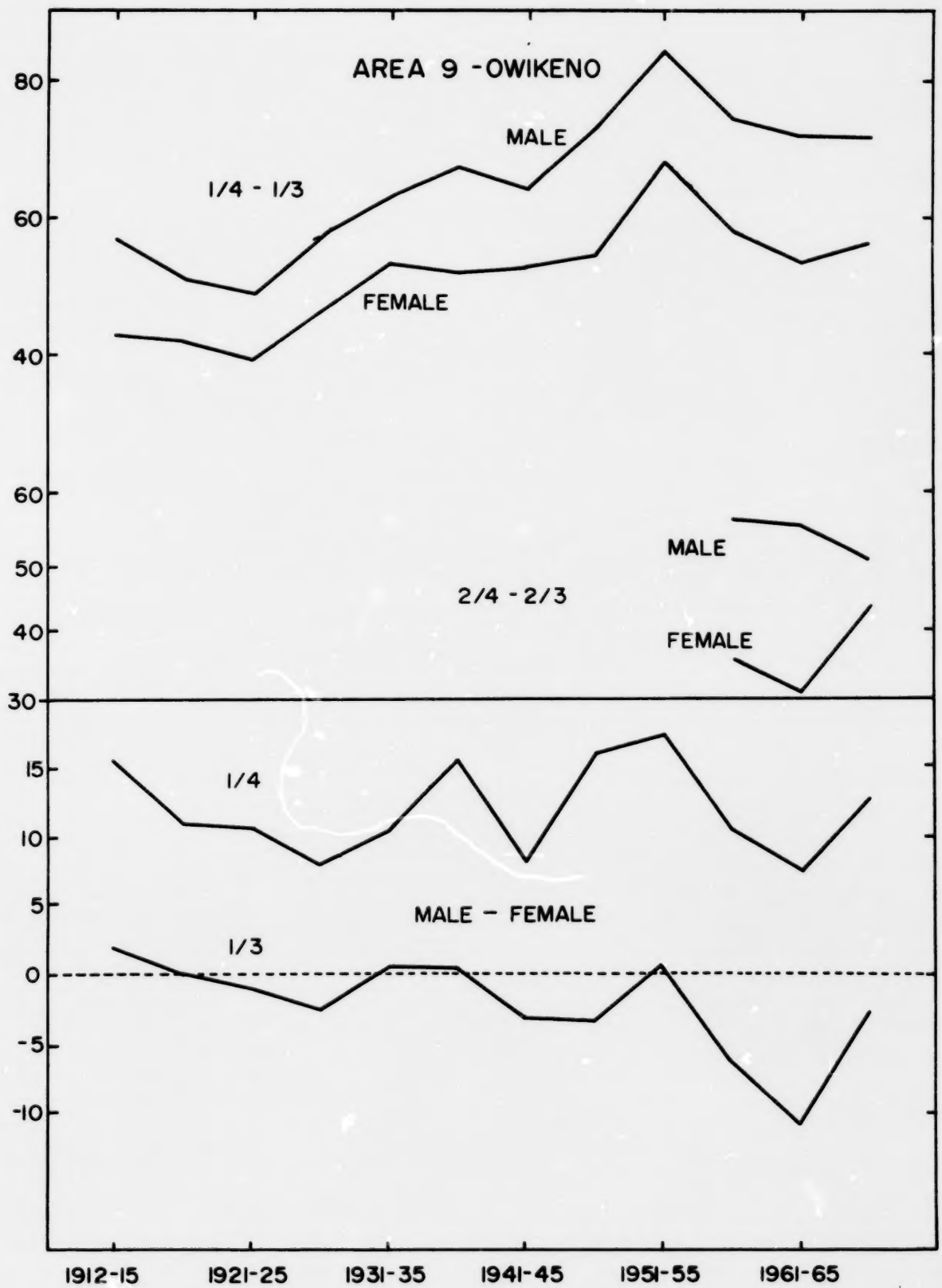


Fig. 17. Five-year mean changes in length of catch samples of Owikeno sockeye (Area 9). Details as in Fig. 15.



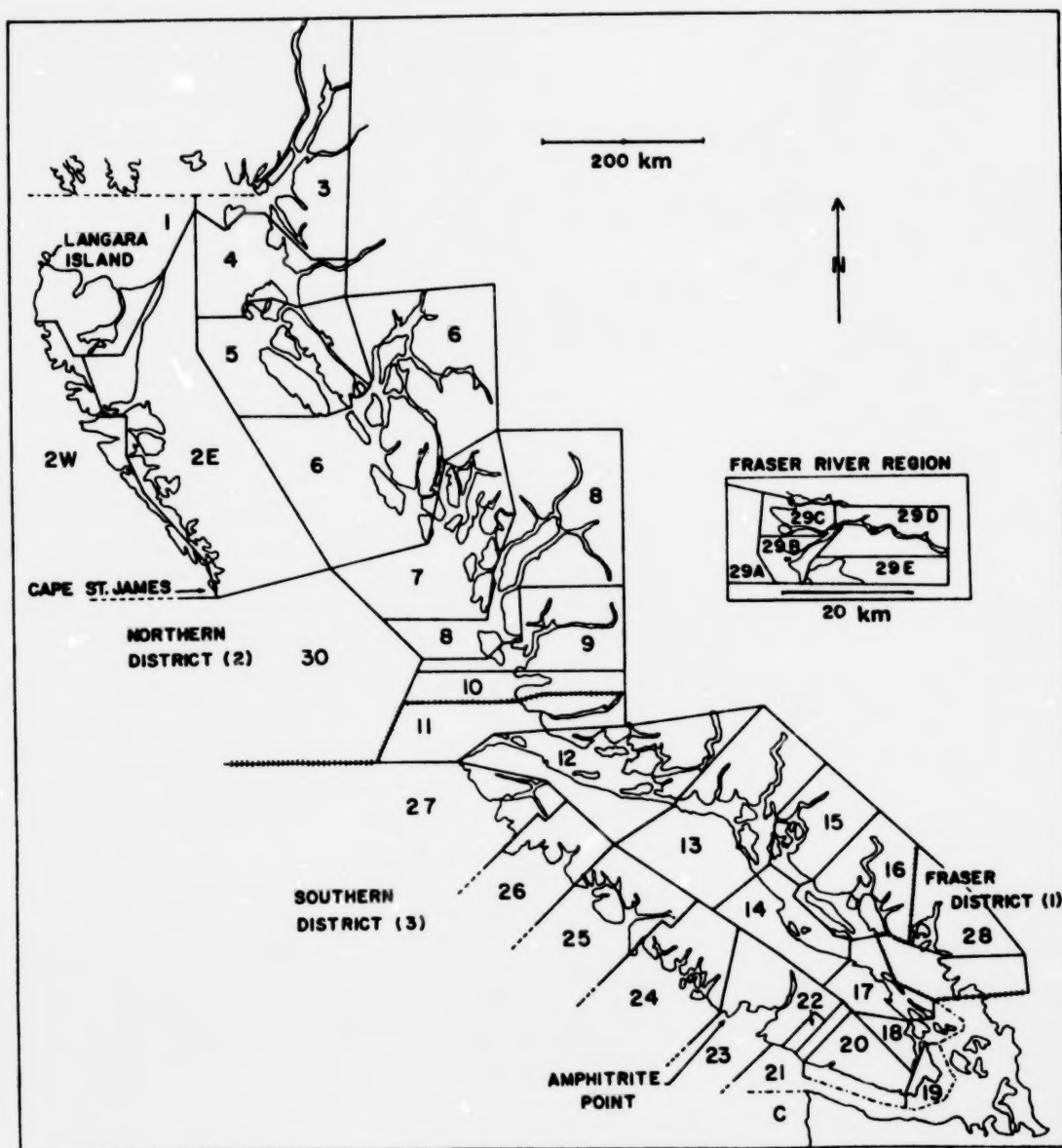


Figure 18. Fisheries statistical Areas of British Columbia.